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A STUDY OF THE CARDIOVASCULAR CHANGES DURING COOLING AND REWARMING IN HUMAN SUBJECTS UNDERGOING TOTAL CIRCULATORY OCCLUSION

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ALTHOUGH therapeutic successes with general hypothermia have been reported for slowing disease processes and for relief of pain,[6, 11] it is only recently that its important role has been recognized in cardiovascular surgery.[2, 3, 4, 7, 12] Reduction of metabolism by hypothermia allows total occlusion of the circulation for a sufficient period of time to permit repair of certain types of vascular and cardiac defects. Our clinical experience with 100 patients undergoing open cardiotomy has indicated that total circulatory occlusion of 8 minutes at a body temperature not lower than 28° C. is relatively safe and affords adequate time to repair interatrial septal defects, pulmonary valvular stenosis, and pulmonary infundibular stenosis.

While numerous studies of cardiovascular physiologic changes occurring during hypothermia in animals have been reported, and several studies of the effect of cold on unanesthetized human beings, there have been relatively few dealing with human patients during hypothermia. With specific reference to the cardiovascular system, Talbott[13] found that the pulse and blood pressure initially rose upon inducing hypothermia in man, and that both then gradually fell as the temperature reached 28° to 32° C. He observed that frequently no

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pulse or blood pressure could be obtained clinically in the cooled state. Much the same observations on pulse and blood pressure were recorded by Kossmann[6] and by Wayburn.[15]

The present study is the first to our knowledge which is concerned with cardiovascular observations made in the operating room throughout the course of intracardiac surgery in patients subjected to general hypothermia with sigmoid temperatures between 26° and 31° C. Primary interest was centered on the effect on the heart rate, blood pressure, and venous pressure under the following conditions: (1) induction and initial stage of hypothermia, (2) total circulatory occlusion, (3) release of occlusion, and (4) rewarming.

METHOD

Details regarding the technique of immersion hypothermia and rewarming used at the University of Colorado Medical Center have been described elsewhere.[12] After premedication with Demerol and scopolamine, the patient was anesthetized with ether, and a No. 18 Cournand needle was placed into the brachial artery. A polyethylene catheter was introduced via an antecubital vein into the subclavian vein or superior vena cava. Pressures were transmitted to a carrier-type recorder. Mean pressures were either electronically integrated or computed with a compensating planimeter. Standard electrocardiogram Lead II was continuously monitored on an oscilloscope and recorded, together with the pressures. In addition, the electocardiogram was relayed to a direct writer.

Base line pressures were taken on the operating table with the patient in surgical anesthesia (third stage, first or second plane). The patient was then placed into a tub of tap water and immersed to the neck. Care was taken to level the strain gauge at the zero point of the right atrium, chosen as a point 10 cm. from the back in the adult and 6 to 8 cm. in the child. Venous pressures could not be recorded while the patient was being cooled, since the catheter was looped above the patient over the edge of the tub. The same was true for the catheter leading from the artery, but here the error introduced by correction for the difference in height between the gauge and the right atrium was not of a significant magnitude.

Ice was added to the water and shortly the temperature of the bath dropped to 5° C. or lower. Shivering was suppressed by the use of d-tubocurarine. Observations were taken every 10 minutes or for every degree fall in temperature. When the desired level was reached, the patient was lifted out of the tub and onto the operating table. During the period of preparation of the patient for surgery it was often difficult to follow the pressures. After the temperature stabilized, pressures were taken every 15 minutes or as desired by the anesthesiologist, who frequently was unable to feel the pulse or obtain a blood pressure. Continuous recording of the entire period of occlusion and the immediate phase of the release was obtained.

When the actual procedure within the heart had been accomplished, rewarming via short-wave diathermy was instituted. Pressures were again taken every 15 minutes up to 34° C., at which point the diathermy was stopped.

RESULTS

As already noted, the studies were done in the operating room during periods of critical surgery. Considerations directly relating to the patient's welfare, of course, took top priority. As a consequence, it was often necessary to compromise in obtaining observations. Complete data were not obtained in every patient at every phase of the study. However, sufficient data were available in the group as a whole to permit some general conclusions.

Further, it should be pointed out that the dynamics of the circulation after release of occlusion were no doubt influenced by blood loss, cardiac manipulation, and the corrective surgery.

Details relating to age of patients, together with the range of hypothermia, diagnoses, and surgical procedures, appear in Table I.

TABLE I. AGE, LOWEST TEMPERATURE AND TYPE OF OPERATIVE PROCEDURE PERFORMED

NO.	PATIENT	AGE (YEARS)	DIAGNOSIS	TEMPERATURE (°C.)	SURGERY
1.	P. S.	7	IASD	26.0	Closure
2.	B. J.	4	IASD-IVSD	28.0	Closure
3.	H. B.	10	IASD	27.0	Closure
4.	S. S.	3	PVS	29.0	Valvuloplasty
5.	L. B.	3	PVS	31.0	Valvuloplasty
6.	H. T.	4	PVS	29.0	Valvuloplasty
7.	R. B. (1)	6	TF	28.0	Valvuloplasty
8.	E. C.	8	TF	28.0	Valvuloplasty
9.	C. Z.	3	PVS	27.0	Valvuloplasty
10.	L. H.	9	IPS	27.0	Infundibulectomy
11.	J. J.	7	IASD	27.0	Closure
12.	R. M. (1)	10	IASD	30.0	Closure
13.	E. H.	13	IASD	27.0	Closure
14.	R. B. (2)	13	IASD	26.0	Closure
15.	R. M. (2)	14	PVS-PDA	29.0	Valvuloplasty; Ligation PDA
16.	E. A.	27	IASD-PDA	26.0	Closure; Ligation PDA
17.	T. G.	32	IASD	26.0	Closure
18.	F. H.	31	IASD	26.0	Closure
19.	H. H.	35	IASD	26.0	Closure
20.	J. St. J.	20	IASD	28.0	Closure
21.	S. P.	17	PVS	28.0	Valvuloplasty
22.	V. K.	26	TF	28.0	Valvuloplasty
23.	C. R.	30	IASD	27.0	Closure

IASD=Interatrial septal defect
IVSD=Interventricular septal defect
TF=Tetralogy of Fallot
PDA=Patent ductus arteriosus
PVS=Pulmonary valvular stenosis
IPS=Infundibular pulmonary stenosis

Adequate data were obtained on 23 patients, ranging in age from 3 to 35 years. All of the patients had congenital heart disease, with most having either interatrial septal defect or pulmonary valvular stenosis. Three patients had tetralogy of Fallot, and 2 others had, in addition to the septal or valvular lesion, an associated patent ductus arteriosus. Hypothermia levels ranged from 26° to 31° C.

Cooling.—During the course of cooling the patient, it was noted that at varying temperature levels the sounds identifying blood pressure by the sphygmomanometer became inaudible and the pulse nonpalpable. This is referred to as "clinical disappearance" of the blood pressures (Table II). In 4 patients, the blood pressures were lost to auscultation even before the rectal

temperature had dropped 1° C. In the rest of the group except one, the blood pressures could not be identified below 31° C. Direct arterial tracings at the time of the "clinical disappearance" showed the blood pressure to be quite adequate.

TABLE II. "CLINICAL DISAPPEARANCE" OF BLOOD PRESSURE AND PULSE DURING COOLING AND RETURN DURING REWARMING

	BLOOD PRESSUBE (MM. HG)				PULSE (PER MINUTE)			
PATIENT	DISAPPEARANCE TEMPERATURE °C.	ACTUAL* PRESSURE	REAPPEARANCE TEMPERATURE °C.	ACTUAL* PRESSURE	DISAPPEARANCE TEMPERATURE °C.	ACTUAL** RATE	REAPPEARANCE TEMPERATURE °C.	ACTUAL** RATE
P. S.	34.0	95/ 62 (73)	35.0	104/66 (75)	--	--	--	--
B. J.	31.0	155/103 (134)	--	--		Palpable throughout		
H. B.	35.8	96/ 64 (80)	33.0	(94)	35.0	102	33.0	126
L. B.	32.9	107/ 56 (80)	--	--	30.0	83	--	--
H. T.	33.2	93/ 45 (67)	--	--	31.0	66	--	--
R. B.	37.0	(78)	32.6	(75)	33.0	60	--	--
E. C.	36.5	120/ 80 (94)	--	--	29.9	54	31.2	60
E. A.	27.6	110/ 78 (95)	32.6	(89)	32.4	48	32.6	60
T. G.	37.0	120/ 86 (93)	33.0	84/56 (67)		Palpable throughout		
F. H.	36.0	(80)	32.6	135/75 (108)	36.0	80	32.6	60
H. H.	32.5	100/ 59 (85)	--	--	31.5	42	29.0	54
J. St. J.	33.0	91/ 61 (77)	32.0	100/59 (80)	33.0	66	32.0	54
S. P.	37.0	73/ 51 (56)	30.0	115/60 (88)	37.0	84	30.0	84

( ) Mean pressure.

*Direct arterial pressure.

**Obtained from electrocardiogram.

"Clinical disappearance" refers to unobtainable blood pressure and nonpalpable pulse. Note the marked variation of temperature levels when changes in both blood pressure and pulse occurred. The blood pressure and pulse at the time of "clinical disappearance" are adequate.

Pulses also were lost to palpation at varying temperatures, usually at levels of cooling lower than the blood pressure disappearance. In 2 patients, B. J., aged 3 years, and T. O., aged 32 years, the pulses were palpable throughout. Rates as determined from electrocardiogram and pulse pressures as determined from recorded contours were slow and adequate, respectively.

Upon rewarming, both vital signs "reappeared" at temperature levels lower than those at which each had disappeared.

As cooling progressed from 36° to 34° C., direct arterial pressure measurements revealed transient elevations in blood pressure, while the heart rate, on the other hand, continued in a progressive decline (Fig. 1). Following this elevation, the blood pressure began to fall to levels considerably below the normothermic levels. After the lowest temperature levels had been reached, two interesting phenomena were observed: (1) the blood pressure continued to fall a significant degree after temperature stabilization at the lowest level; (2) conversely, the heart rate did not alter appreciably during this interval of time. On the average, 30 minutes elapsed between the time of the lowest temperature stabilization to lowest blood pressure stabilization.

There was no change in pulse pressure in those patients cooled to a temperature not less than 28° C. Below this point there was a progressive precipitous drop through the ranges observed, 28° to 26° C. (Fig. 2). On rewarming, the pulse pressure increased above normal for the group as a whole.

On cooling there occurred an increase in venous pressure from the post-anesthetic but still normothermic level, with the largest increases being observed in patients cooled to the lower temperature levels (Table III). On rewarming, 3 of 5 patients in whom adequate rewarm data were obtained had persistently elevated venous pressures above normal.

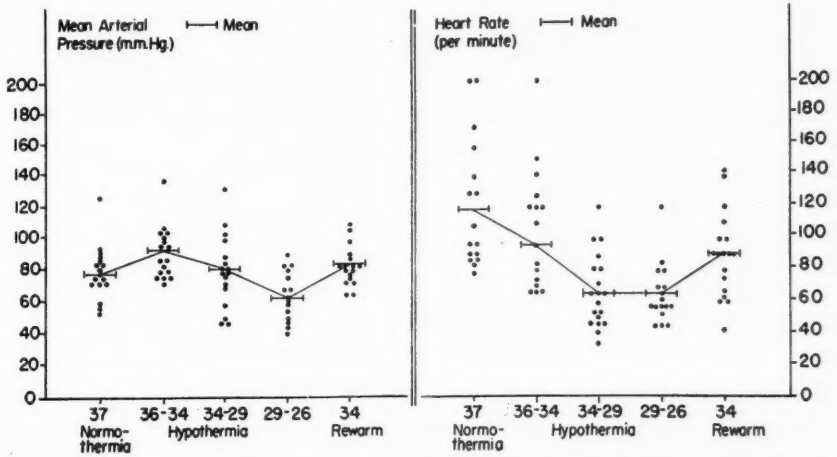

Fig. 1.—Blood pressure and pulse rate changes during cooling and rewarming. As cooling proceeds there is a transient rise in blood pressure, whereas the heart rate progressively declines. Thirty minutes after lowest temperature is reached the blood pressure has further declined although the heart rate remains stable. On rewarming to 34° C., the blood pressure returns to normal, while the heart rate remains low.

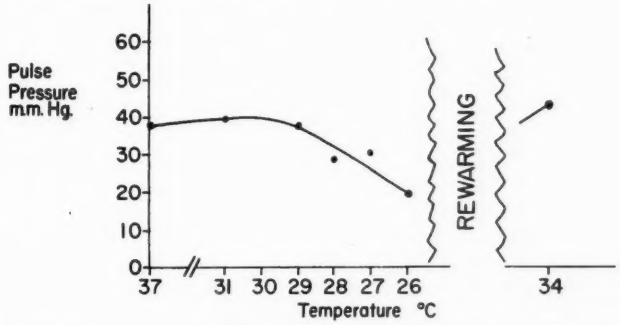

Fig. 2.—Pulse pressure changes during hypothermia and rewarming. There is no change in pulse pressure until the temperature drops below 29° C. Each point represents the means of the final, stabilized temperatures.

Total Circulatory Occlusion.—Adequate data during total circulatory occlusion were obtained in 16 patients and are summarized in Table IV.

Immediately upon occlusion, blood pressures in all of the patients fell. Generally they were stabilized at their lowest level within one or 2 minutes, although in patients with occlusions maintained beyond 4 minutes a slight additional fall usually occurred.

TABLE III. VENOUS PRESSURE CHANGES DURING HYPOTHERMIA AND REWARMING

	NORMOTHERMIA		HYPOTHERMIA			REWARM		
PATIENT	TEMPERATURE	V. P. (MM. HG)	TEMPERATURE	V. P. (MM. HG)	DIFFERENCE	TEMPERATURE	V. P. (MM. HG)	DIFFERENCE
E. A.	37	3	26	8	+5	32	6	+3
P. S.	37	3	26	11	+8	–	–	–
F. H.	–	–	26	7	–	35	8	–
H. H.	37	12	26	4	–8	32	4	–8
R. B.	37	1	29	5	+4	33	3	+2
S. P.	37	5	29	7	+2	–	–	–
J. St. J.	37	7	29	10	+3	33	7	0
H. B.	37	8	27	10	+2	33	14	+6

All pressures were taken with the chest intact; the comparisons are with the precooling normal. On cooling, an increase in venous pressure occurs which tends to persist to the late phase of rewarming.

TABLE IV. MEAN ARTERIAL BLOOD PRESSURE AND HEART RATE DURING TOTAL CIRCULATORY OCCLUSION AND RELEASE

PATIENT DEFECT	TEMPERATURE (°C.)	IMMEDIATE PRE-OCCLUSION		OCCLUSION (TIME IN MINUTES)									RELEASE (TIME IN MINUTES)						
				IMMEDIATE	.25	.5	1	2	3	4	5	6	IMMEDIATE	.25	.5	1	5	15	30
F. H.	26	B.P.	64	--	55	--	70	55	47	42	50	42	45	45	56	54	80	76	65
IASD		H.R.	60	--	75	--	75	30	45	30	30	30	--	30	30	30	36	36	40
H. B.	27	B. P.	85	--	36	29	31	25	25	25	29	29	17	61	67	105	89	63	72
IASD		H.R.	60	--	96	90	90	42	20	24	30	42	60	48	36	50	66	66	78
P. S.	26	B.P.	78	59	48	34	--	--	--	--	--	--	--	--	20	30	--	57	72
IASD		H.R.	84	84	84	84	--	40	24	--	--	--	24	30	30	30	--	36	70
T. G.	26	B.P.	43	--	--	--	--	--	--	--	--	--	18	23	40	34	43	56	66
IASD		H.R.	60	--	50	20	--	24	24	24	24	--	24	24	24	24	30	24	30
E. H.	27	B.P.	91	--	--	--	47	29	32	--	25	--	--	--	87	96	85	46	105
IASD		H.R.	120	--	--	--	--	110	40	--	50	--	--	--	120	110	110	--	100
L. H.	27	B.P.	64	61	--	35	19	24	24	26	19	--	--	--	35	36	--	--	60
IPS		H.R.	110	80	120	120	110	80	60	60	60	--	--	--	70	40	--	--	120
C. Z.	27	B.P.	95	--	--	--	25	25	--	--	--	--	56	--	60	80	68	60	55
PVS		H.R.		(Not obtained)															
B. J.	28	B.P.	82	--	60	54	49	46	40	40	40	40	46	93	69	97	57*	80	88
IASD		H.R.	80	--	80	80	70	50	50	30	57	57	40	40	40	40	48	66	78
R. M. (2)	29	B.P.	57	41	49	24	24	24	18	--	--	--	28	47	46	--	66	--	53
PVS-PDA		H.R.	72	72	60	60	--	60	60	--	--	--	64	--	--	--	70	66	70
S. P.	28	B.P.	60	--	33	25	20	18	18	25	--	--	30	28	32	--	50	--	85
PVS		H.R.	60	--	66	72	42	42	42	42	--	--	66	66	66	--	54	--	54
R. B. (1)	28	B.P.	76	79	50	34	28	14	14	--	--	--	90	--	--	--	--	--	83
TF		H.R.	60	--	--	--	--	--	--	--	--	--	72	--	--	--	--	--	96
L. B.	31	B.P.	80	48	29	27	27	27	27	--	--	--	60	94	100	100	120	95	88
PVS		H.R.	120	100	120	120	48	60	96	--	--	--	130	126	100	100	120	72	72
E. C.	28	B.P.	40	36	--	27	27	24	19	19	16	--	27	52	73	71	--	--	67
TF		H.R.	80	50	--	40	40	80	30	24	28	--	50	60	50	50	54	--	60
J. St. J.	28	B.P.	69	47	40	27	38	30	30	30	16	21	34	78	116	107	80	73	67
IASD		H.R.	54	70	90	80	72	36	30	54	72	54	60	66	80	30	60	60	42
H. T.	29	B.P.	59	--	51	35	30	35	--	--	--	--	--	51	53	47	64	85	69
PVS		H.R.	72	--	80	90	60	60	--	--	--	--	--	60	60	50	60	72	72
R. M. (1)	30	B.P.	59	24	25	24	26	26	22	20	--	--	88	96	103	--	102	81	78
IASD		H.R.		(Not obtained)															

*Ventricular fibrillation—defibrillated.
B.P.=blood pressure.
H.R.=heart rate.

Five of the patients showed an acceleration in heart rate immediately postocclusion. The heart rates from this point throughout the occlusion were conditioned by two factors, other than the level of cooling: (1) the coronary perfusion of neostigmine, which slowed the rate; and (2) manipulation of the heart, which created bursts of acceleration, especially idioventricular beats. The heart rate slowed during circulatory occlusion in most patients, the major change usually occurring rather abruptly between ½ and 2 minutes following onset of occlusion, or 15 seconds to 1½ minutes after the perfusion of neostigmine. These data are tabulated in Table V. In general, slightly larger doses were used in patients with the large hearts of atrial septal defects.

TABLE V. CHANGE IN HEART RATE DURING CIRCULATORY OCCLUSION AND DOSAGE OF NEOSTIGMINE USED

PATIENT	DIAGNOSIS	DOSE OF NEOSTIGMINE (MG.)	HEART RATE	
			PRIOR TO NEOSTIGMINE	AFTER NEOSTIGMINE
P. S.	IASD	0.25	84	40
T. G.	IASD	0.25	90	42
F. H.	IASD	0.22	50	24
H. B.	IASD	0.20	70	55
B. J.	IASD IVSD	0.13	80	50
J. St. J.	IASD	0.25	80	36
E. C.	TF	0.20	80	30
S. P.	PVS	0.22	72	42
H. T.	PVS	0.17	90	60
R. M.	PVS PDA	0.13	60	60

The venous pressure rose on occlusion in 7 of 8 patients studied (Table VI). In the eighth patient (E. H.), there was no significant rise. As the occlusion was maintained, in 5, the pressure began to fall, in 2 instances (F. H. and J. St. J.), dropping below the preocclusion control levels. In 2 of the subjects (L. H. and H. B.), following the drop there developed a second elevation, occurring during the latter phases of the occlusion.

Release of Occlusion.—Upon release of the occlusion in the temperature range 28° to 31° C., 6 patients showed an immediate overshoot of the blood pressure beyond preocclusion control levels. The overshoot developed within 5 to 30 seconds (Table IV). None of the patients below 28° C. developed an immediate overshoot; one patient (H. B.), however, developed a delayed elevation in pressure one minute after release. (One minute may be too long to be classed as a reflex reaction, even at a low heart rate.) After 30 minutes, the blood pressure of all patients (with one exception, R. M. [2]) was as high or higher than preocclusion. Of the 6 patients showing the overshoot, 2 had an accompanying fall in pulse rate, reaching its maximum within one minute of the release. In 3, the pulse rates were stable. Over a 15- to 30-minute period, the heart rates gradually returned to preocclusion levels.

The periods of occlusion (between 2 and 6 minutes) bore no direct relationship to the development, degree, or recovery of the blood pressure overshoot. Neither the basal preocclusion pressure levels nor the type of cardiac malformation appeared to have any effect on the presence or character of the overshoot.

The venous pressures fell immediately upon release of occlusion (Table VI), and by 30 minutes were at or below preocclusion levels, except R. M. (1) in whom the pressure remained elevated.

TABLE VI. VENOUS PRESSURE (MM. HG) DURING OCCLUSION AND ON RELEASE (OPEN CHEST)

PATIENT	TEMPERATURE °C.	PREOCCLUSION HYPOTHERMIA	OCCLUSION (TIME IN MINUTES)								RELEASE (TIME IN MINUTES)					
			IMMEDIATE	.5	1	2	3	4	5	6	IMMEDIATE	.5	1	5	15	30
P. S.																
IASD	26	13	19	18	18	18	16	--	--	--	13	8	8	--	4	5
F. H.																
IASD	26	9	10	10	10	6	3	2	3	4	5	9	10	10	10	7
H. B.																
IASD	27	8	22	22	19	20	21	21	27	27	15	10	10	8	10	10
C. Z.																
PVS	27	14	29	--	21	22	--	--	--	--	9	--	10	10	9	--
C. R.																
IASD	27	3	--	--	23	19	21	--	--	--	8	--	8	7	--	0
L. H.																
IPS	27	2	--	--	--	8	5	5	9	--	--	8	8	--	--	3
J. St. J.																
IASD	28	10	10	21	21	14	10	4	1	1	1	0	-1	0	0	0
R. M. (1)																
IASD	30	5	28	21	21	23	21	19	--	--	--	--	19	16	8	12

SUMMARY OF RESULTS

The blood pressure and pulse could not be obtained by the usual clinical methods after various levels of cooling had been achieved. Direct arterial tracings, however, demonstrated adequate blood pressures and rates at the times of "clinical disappearance." On rewarming, the blood pressure and pulse "reappeared" usually at a lower temperature than that at which each had previously been lost to auscultation or palpation. During cooling, an early transient elevation in blood pressure was observed while the heart rate declined progressively. The blood pressure subsequently began to fall, and stabilized at its lowest level 30 minutes after the sigmoid temperature had become stabilized. The heart rate, however, reached its lowest level at the same time as the temperature. The magnitude of blood pressure and pulse rate changes varied considerably from patient to patient in all temperature ranges. The pulse pressures declined in the lower temperature ranges (below 28° C.). Rewarming with diathermy was discontinued at 34° C., at which time, however, the blood pressure and pulse rate were substantially within normal limits for the group as a whole.

The venous pressure became elevated during hypothermia. On rewarming, a continued elevation of the venous pressure above normal occasionally remained.

At the onset of total circulatory occlusion, the blood pressure dropped sharply, and, as occlusion was maintained beyond one minute, dropped still further, although it rarely fell below a mean of 20 mm. Hg. Upon release of occlusion, an immediate overshoot above preocclusion levels was observed in 6 of 9 patients not cooled below 28° C. In the group cooled below 28° C., one of 7 showed an overshoot, and this was a delayed one.

Following onset of occlusion, the heart rate fell in all patients, usually reaching its maximum decrease in from 30 seconds to 2 minutes. Neostigmine was administered by coronary perfusion from 15 seconds to one minute following occlusion. On return of circulation, the pulse rate returned to preocclusion levels after 5 to 15 minutes.

The venous pressure rose on occlusion in 7 of 8 patients, then tended to fall as the occlusion was maintained. Upon release, the pressure tended to return toward preocclusion control levels within 15 to 30 minutes.

DISCUSSION

Talbott,[13] in his studies on patients cooled in air, noted an initial rise in both blood pressure and pulse rate. Similar observations were made by Collins and Granatelli,[3] by Kossmann,[6] and by Wayburn.[15] It would be difficult to make comparisons between the observations of this report and those just mentioned, due to the fact that our patients were the only ones cooled rapidly by ice water immersion. We observed a transient rise in blood pressure, but no rise in pulse rate—in fact, a fall. The elevation of blood pressure during immersion cooling, with a fall in rate, is a response, we believe, to the intense vasoconstriction which occurs early in the cooling process. The temperature levels at which these elevations were noted varied from 37° to 34° C., sigmoid temperature. At this point, however, the skin vessels are widely dilated due to the direct paralysis of cold. (The skin of the patient is bright pink). The blood pressure thus remains temporarily elevated, even though the skin vessels have become dilated. This maintenance of blood pressure above normal was probably due to persistent vasoconstriction of the internal vessels. The later drop in blood pressure as cooling continues, we believe, was due to a fall in cardiac output and not to a release of the peripheral resistance.

The "clinical disappearance" of the blood pressure and pulse is an interesting phenomenon. It was observed by Collins,[3] Kossmann,[6] and Talbott.[13] Talbott further noted that the blood pressure must have been adequate at the times of "disappearance" since puncture of an artery resulted in a forceful jet of blood. This observation is confirmed in the present study. The blood pressure was lost first and then the pulse. The mechanism of the "clinical disappearance," we believe, lies in the physical state of the large arteries during cooling. Early in cooling the larger vessels are unaffected because the blood temperature has not appreciably changed. Not until the intense peripheral vasodilatation has occurred does the blood begin to cool. Circulation of cool blood through human arteries causes intense constriction of these vessels, as has been demonstrated by Bazett and his associates.[1] Thus, once the

blood begins to cool, the larger arteries become rigid, and the mechanism essential to auscultatory blood pressure determinations[16] is lost. The phenomenon has nothing to do with pulse pressure, which does not show any significant change until long after the blood pressure "disappearance" has occurred. A pulse wave, of course, persists at least for a time, and is palpable. Thus, the palpable pulse is lost after the blood pressure.

It is important to realize that even though these clinical signs "disappear," the blood pressure and pulse are quite adequate as measured directly. This emphasizes the value, in fact the necessity, of monitoring heart rate by means of electrocardiography through the cooling experience. In addition, the presence of an inlying arterial cannula and pressure recording device is highly desirable.

The observed elevation in venous pressure which begins during cooling and persists throughout the experience might be explained as follows. As the cardiac output progressively falls during cooling, blood accumulates on the venous side of the systemic circulation. Normally, this would cause little change in pressure until severe venous distention occurred because of expansion in venous reservoirs. These changes in venomotor tone are normal reflex responses to volume changes.[16] As the blood cools, however, the same constrictive effect seen in the arteries occurs in the veins.[1] Under these circumstances, the flexibility of the venous reservoirs is lost and volume changes are reflected in rising pressure. Venous pressure still remains high, however, even after stabilization of cardiac output when hypothermia has been achieved and also during rewarming when cardiac output is actually increasing. The explanation for this is not at all clear.

During total circulatory occlusion, the blood pressure reached its low point within 2 minutes, yet in most instances remained well above zero, despite the fact that there was absolutely no cardiac output. Whether osmotic phenomena play a role in this "cadaver" pressure, we cannot say.

It was noted that the heart rate fell acutely, usually after 30 seconds to 2 minutes of occlusion. On the basis of previously reported experimental evidence,[12] it is our uniform practice to cross-clamp the aorta about one inch from the heart and inject about 0.2 mg. of neostigmine into the root of the aorta to perfuse the coronary circuit with the drug. This maneuver is usually completed at 45 seconds to one minute of occlusion. We believe this agent was an important factor in the observed slowing of the heart, although inflow occlusion alone may also play a part. That it is possible to slow or, in fact, stop the heart with neostigmine is well known.[14] In the observations reported here, the decrease in heart rate occurred usually within 15 or 90 seconds following completion of the neostigmine injection. This agent may also have been a factor in the slow return of rate following release of occlusion in some patients.

The venous pressure prior to occlusion was elevated above normal. Upon total circulatory occlusion, a further rise in pressure of considerable magnitude was usually seen. This would appear to be due to sudden damming of

blood in an already overloaded constricted system. It is of interest that in 2 of the 4 cases, as the occlusion was maintained, the venous pressure fell below the preocclusion level and, in one of these, even below the normothermic level. The explanation for the venous pressure fall while the occlusion was maintained is conjectural.

Upon release of occlusion and return of circulation, the blood pressure showed an interesting immediate elevation above preocclusion levels in 5 patients, a phenomenon we have referred to as "overshoot." In 2 patients, the peak of the overshoot coincided with a slowing of pulse rate. This reaction is not unlike the course of events following the Valsalva maneuver in normal individuals.[5, 8] The principal post-Valsalva circulatory events are mainly reflex in character, as are those following release from total circulatory occlusion. The differences noted are primarily quantitative and are possibly related to the body temperature level; i.e., in hypothermia the magnitude of response is less and the time interval of the events prolonged. For example, during normothermia following release of a Valsalva maneuver, the overshoot reaches its peak in 4 or 5 seconds at a normal heart rate of 70 to 90 per minute.[8] During hypothermia, the time required to reach the peak varied between 5 and 30 seconds, with the majority requiring over 15 seconds, but with heart rates of only 30 to 50. No such overshoot was seen in 3 patients whose temperatures fell to 26° C. It is possible that this degree of hypothermia is sufficient to inhibit completely the reflex pathways involved in the response, although some baroceptor responses appear to be still present, at this temperature level.[10]

By and large, however, it may be concluded on the basis of the data presented that the cardiovascular reflex mechanisms regulating the circulation are intact in the range of hypothermia studied (26 to 31° C.), although they may be somewhat slowed.

SUMMARY AND CONCLUSIONS

1. The effects on the cardiovascular system of cooling and rewarming were studied in 23 patients undergoing hypothermia, total circulatory occlusion, and intracardiac surgery.

2. Upon cooling there was a transient elevation in blood pressure, followed by a fall which was not maximum until 30 minutes after sigmoid temperature had reached its lowest point.

3. The pulse rate fell progressively with cooling and the temperature and rate reached lowest levels simultaneously.

4. Blood pressures and pulses were lost to auscultation and palpation at varying points during cooling. At the times of the "clinical disappearance," both blood pressure and pulse rate were quite adequate, as demonstrated by direct measurements. The mechanism of this phenomenon is discussed.

5. The magnitude of eventual blood pressure and heart rate changes varied considerably between patients and appeared to have no direct relationship to age and type of heart disease.

6. Venous pressure rose on cooling and remained elevated. Possible mechanisms underlying this phenomenon are discussed.

7. During total circulatory occlusion, the blood pressure fell, the heart rate (following neostigmine injection) slowed abruptly, and venous pressure at first rose, then fell in some instances.

8. Following return of circulation, an immediate overshoot of blood pressure occurred, while venous pressure dropped abruptly.

9. During rewarming, all the circulatory signs have returned to within normal limits at 34° C.

10. Cardiovascular reflexes governing the circulation appear to be intact and adequate in human beings undergoing hypothermia in the range 26° to 31° C.

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ARTERIOVENOUS FISTULA OF THE RIGHT INTERNAL MAMMARY VESSELS FOLLOWING RADICAL MASTECTOMY: VISUALIZATION BY ANGIOCARDIOGRAPHY

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TRAUMA incident to en masse ligation of vessels during surgical operations has become recognized as a cause of arteriovenous fistulas. In the case herein described, an internal mammary arteriovenous fistula developed following right radical mastectomy for carcinoma. The arteriovenous fistula was visualized by the method of angiocardiography. At operation, a silk ligature was found around the vessels; individual ligation of the vessels and excision of the fistulous sac were curative. To our knowledge, an arteriovenous fistula of the internal mammary vessels following surgery has not been previously reported.

CASE REPORT

A 48-year-old housewife (N. Y. H. No. 74274) was admitted on Sept. 20, 1955, complaining of a continuous vibration of the right anterior chest and a buzzing noise along the right side of the neck. Two years prior to entry she had had a right radical mastectomy at another hospital because of cancer of the breast. The operative note indicated that the procedure was carried out in a routine manner and without difficulty; there was no excessive bleeding. The postoperative course was uneventful except for pain in the anterior chest which persisted for several months. Six months following operation, tenderness and vibrations over the right anterior chest and a whistling noise along the right neck began. Despite these symptoms, several months elapsed before the characteristic bruit was recognized and the diagnosis of arteriovenous fistula made.

In the past, the patient had been well except for dysmenorrhea. The only significant illness was the carcinoma of the breast at age of 46 years. Physical examination revealed a well-developed and well-nourished woman in no distress. Examination of the thorax disclosed a well-healed scar of a right radical mastectomy; the pectoral muscles were absent. In the second right anterior interspace near the sternum, there was a 5 by 5 cm. swelling which felt soft and contained a coarse thrill. A loud bruit was clearly audible; loud, rough, machinery-like systolic and diastolic murmurs were heard with the stethoscope. The heart was normal in size and there were no cardiac murmurs. The blood pressure was elevated, 194/104 mm. Hg. The lungs were clear. A few firm, small axillary and inguinal lymph nodes were palpable. The rest of the examination, including the pelvic organs, was normal.

Laboratory data, including x-ray examinations of the heart, lungs, sternum, ribs, thoracic spine, and long bones, were normal. Angiocardiography was done in the frontal and lateral positions on Sept. 20, 1955. Films were made at one-second intervals and showed the right innominate vein, superior vena cava, right atrium and ventricle, pulmonary arteries and branches to be normal. The pulmonary veins, left atrium and ventricle,

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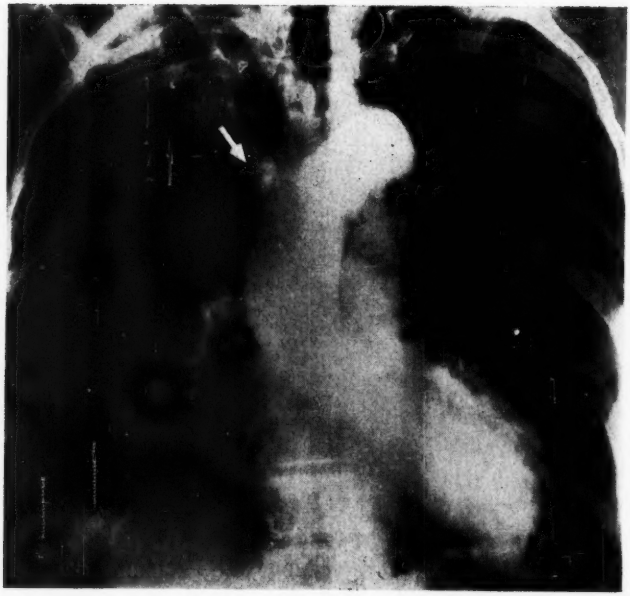

Fig. 1.—Angiocardiogram (frontal view) made 9 seconds after the beginning of injection shows opacification of the left ventricle and aorta. The brachiocephalic arteries including the right internal mammary artery (arrow) are clearly outlined. Note the cluster of opacified vessels at termination of the right internal mammary artery, the site of the arteriovenous fistula.

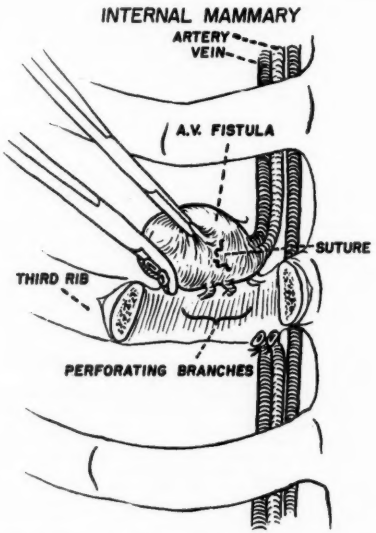

Fig. 2.—Sketch of the operative findings of the right internal mammary arteriovenous fistula which developed after radical mastectomy.

and aorta were also of normal size and contour. At the time of filling of the aorta and brachiocephalic arteries, the right internal mammary artery was also visualized and its termination in a cluster of vessels measuring about 1.5 cm. in diameter was clearly demonstrated (Fig. 1).

At operation on Sept. 23, 1955, drapings were arranged to expose the entire anterior chest wall from the level of the clavicles down to the costal margins and between the anterior axillary lines. At the level of the third right interspace there was a 5 by 5 cm. pulsatile area raised about ½ cm. above the tissues. On palpation, a thrill was felt, and compression against the third rib caused it to disappear.

A skin flap with its base cephalad and just large enough to incorporate the lesion was made. The skin flap was dissected free and a pulsating mass exposed. The third rib was then resected from its junction with the sternum for a distance of about 12 cm. The right internal mammary vessels were visualized and the arteriovenous fistula inspected. When the fistula was dissected apart, a black suture, probably the site of ligature and cause of the arteriovenous fistula was revealed (Fig. 2). The arteriovenous fistula was dissected free and the individual vessels ligated. Complete collapse of the fistulous sac resulted; there was also disappearance of the thrill and murmurs. Numerous perforating branches from the intercostal vessels were individually ligated allowing removal of the fistula and aneurysmal sac. The skin flap was then brought into position and secured with interrupted sutures of pure silk to the subcutaneous tissue and skin. A pressure dressing with rubber sponge was applied to avoid accumulation of blood and serum under the skin flaps. Recovery was uneventful and the patient was discharged on the twelfth postoperative day.

Pathologic study of the specimen revealed a saclike structure measuring 2 by 1.8 by 1.5 cm.; several "feeder" vessels were present. Microscopic study showed the sac to be composed of a thick layer of connective tissue with connecting endothelium-lined blood vessels.

COMMENT

Injuries to blood vessels have been recorded ever since the beginning of medical history and go back to the era of blood letting. Elkin[1] aptly remarked that although blood letting has long passed into oblivion, a new evil, the large scale use of venous and arterial punctures for diagnosis and treatment may be expected to be followed by an increased number of aneurysms and fistulas. However, such complications have been rare. Trauma to blood vessels during surgical procedures is common; transfixion and ligation of individual vessels are standard procedures. Ligation of arteries and veins en masse, however, is particularly liable to give rise to fistulas. Holman[2] also has emphasized the danger of erosion of ligatures, particularly after mild infection. It is generally agreed that traction pins, wires, and fixation devices are dangerous in the vicinity of blood vessels because of their tendency to erode vessels and cause arteriovenous fistulas.[3, 4]

Arteriovenous fistulas have been described following thoracentesis,[5] amputations,[6] hysterectomy,[7] thyroidectomy,[8] laminectomy for intervertebral discs,[9] and nephrectomy.[10] Elkin[1] reported three instances of aneurysm and 3 cases of arteriovenous fistulas following operations or surgical procedures in 650 personally observed cases; a total incidence of one per cent.

In the case herein reported, the onset with pulsation in the chest wall and vascular bruit following mastectomy was characteristic of the development of a traumatic, postsurgery arteriovenous fistula. Localization of the lesion to

the right internal mammary vessels was easily accomplished by the intravenous method of angiocardiography.[11] Furthermore, visualization of the arteriovenous fistula excluded other (congenital) types such as chest wall,[12] pulmonary,[13] and coronary.[14] Finally, the normal cardiovascular findings also eliminated patent ductus arteriosus, aortic septal defect, and rupture of an aortic sinus aneurysm. The finding of an old ligature in the immediate vicinity of the fistula is strong evidence that erosion was responsible for formation of the arteriovenous connection. Surgical excision of acquired arteriovenous fistulas with ligation of the involved vessels is curative.

ADDENDUM

Since this paper was submitted for publication, Muller and Goodwin[15] reported operating on a patient with a renal arteriovenous fistula which was discovered 29 years after nephrectomy.

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PERICARDIAL FAT NECROSIS

Report of Three Cases

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EXPLORATORY thoracotomy has justifiably become an increasingly common and accepted procedure. It is frequently the most expedient or the only method available to establish a definitive diagnosis, without which intelligent management is impossible. The following three clinically indeterminate chest lesions were surgically excised and are reported because of their unusual nature. They represent a clinicopathologic entity to which we can find no reference in the medical literature.

REPORT OF CASES

Case 1.—A 52-year-old white male farmer registered at the Mayo Clinic on Aug. 23, 1951. For approximately one year he had experienced intermittent episodes of severe sharp lancinating pain in the lower aspect of his right anterior chest. In June, 1951, he had been hospitalized for a particularly severe attack of constant pain which was aggravated by deep breathing. A thoracic roentgenogram was interpreted as normal at that time, but a repeat study in August revealed a lesion in the right hemithorax and he was referred to us for evaluation. He gave a history of pneumonia with pleurisy on the right side in 1929 and removal of a squamous-cell epithelioma from the left eyelid in May, 1951. A mobile-unit roentgenogram of the thorax in 1949 had been normal.

On physical examination the patient appeared in excellent general health, except for moderate obesity. He was 66 inches in height and weighed 185 pounds. Definite point tenderness to palpation was present over the costochondral junction of the right fifth rib. No other significant findings were noted.

No abnormal data were recorded in a thorough laboratory study including an electrocardiogram. Posteroanterior and left anterior oblique roentgenograms of the chest (Fig. 1) demonstrated a mass over the dome of the right diaphragm in continuity with the chest wall.

On Aug. 29, 1951, a right anterolateral incision was made and the chest was entered through the bed of the fifth rib. A firm mass of lobulated fat was found surrounded by a moderate degree of inflammatory reaction fixing it to the diaphragm, the anterior chest wall, and the right lower lobe. Curiously, it was attached to the pericardium by a pedicle 3 cm. in length and 0.7 cm. in diameter. This was ligated, and the mass was removed after it had been freed by means of sharp dissection. An unusually large amount of lobulated fat was noted overlying the parietal pericardium.

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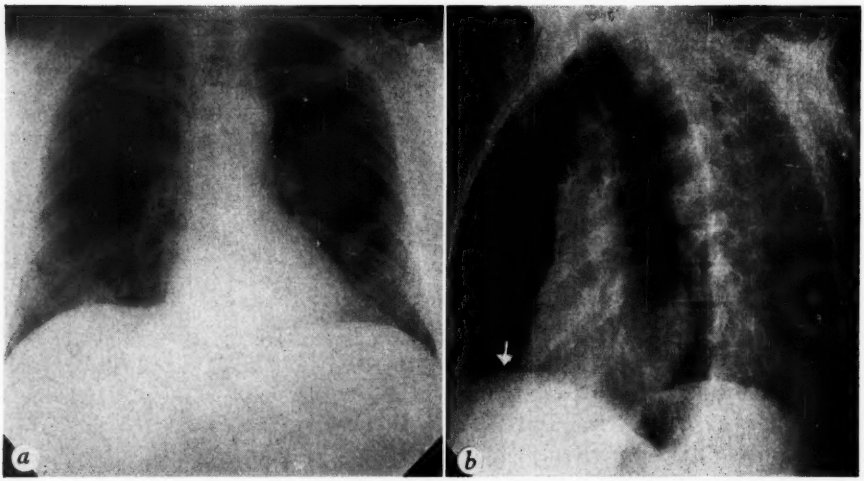

Fig 1.—Case 1. Posteroanterior (*a*) and left anterior oblique (*b*) roentgenograms. The pedicle found at operation is clearly demonstrated in *b* (arrow).

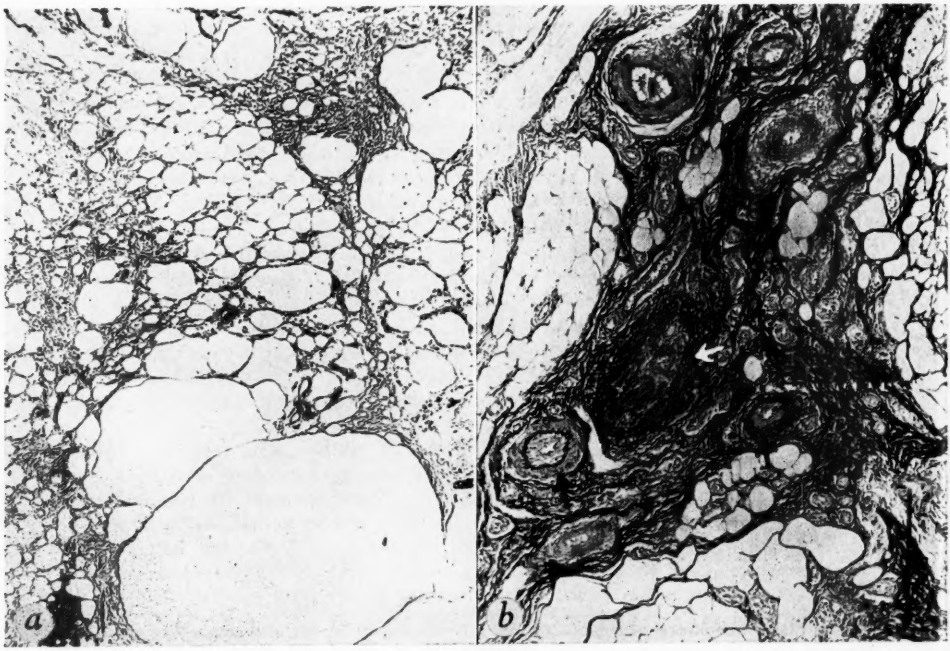

Fig. 2.—Case 1. *a*, Section showing pooling of fat in compartments of varied size. The cells in the cellular areas are largely lipide-laden macrophages (hematoxylin and eosin; ×40). *b*, Section illustrating a severe degree of subintimal fibrosis of arterioles (black arrows) and a thrombosed vein (white arrow) (elastic van Gieson; ×75).

The gross specimen measured 5 by 2.5 by 2 cm. It was firm and was composed entirely of fat, which was medium to light brown. Microscopic sections (Fig. 2, *a*) demonstrated fat necrosis. There were definite phagocytosis of some of the fat and pooling of the lipides in large spaces, frequently 10 to 20 times the diameter of a normal fat cell. A moderate amount of fibrous tissue was present in heavy strands and islands throughout the specimen. There was very little inflammatory exudate. Serial block sections were prepared with elastic van Gieson stain (Fig. 2, *b*). Some of the arterioles demonstrated a severe degree of subintimal fibrosis and others a mild to moderate medial hypertrophy with consequent narrowing of the lumina. Several small venules had thrombosed and partially recanalized. The majority of the vessels, however, were quite normal.

CASE 2.—A 63-year-old white male truck driver registered on May 2, 1955. Six weeks previously a very severe pain had abruptly developed in the left precordium. He had had a myocardial infarction four years previously, and both he and his physician thought he was suffering from a similar attack. A low-grade fever and nonproductive cough developed during subsequent hospitalization, and an electrocardiogram showed no

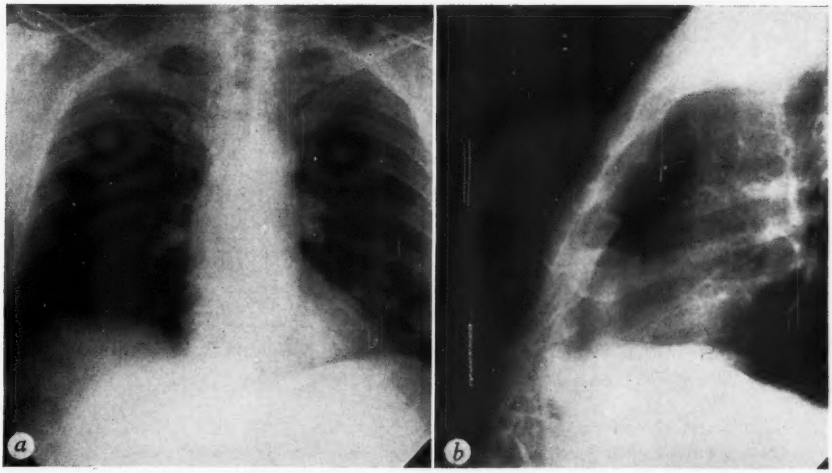

Fig. 3.—Case 2. Posteroanterior (*a*) and left lateral (*b*) roentgenograms, showing rounded opacity overlying the left heart border and anterior against the chest wall.

change. The pain gradually diminished and became intermittent, but was referred to the left shoulder and was aggravated by a cough. Thoracic roentgenograms demonstrated a lesion which did not change over a 6-week interval, despite antibiotic therapy. Consequently, he was referred to the Clinic for further study. His past medical record included a coronary occlusion in 1951 and ligation of the left saphenous vein in 1947. Chest roentgenograms in 1952 and 1953 were normal.

Physical examination revealed a somewhat obese, mentally depressed man, who did not appear ill. He was 70 inches tall and weighed 220 pounds. Moderate benign prostatic hypertrophy was noted, but other findings were quite normal. His exercise tolerance was excellent.

Laboratory studies were within the usual range, except for an electrocardiographic tracing indicative of an ancient healed posterior myocardial infarct. Posteroanterior and lateral thoracic roentgenograms (Fig. 3) demonstrated a rounded juxtacardiac mass.

On May 6, 1955, a left posterolateral incision was made through the bed of the sixth rib. A firm, ovoid mass was encountered, which was densely adherent to the anterior chest

wall, pericardium, and lung. It appeared to originate in pericardial fat and was dissected away and removed without damage to the lung or the pericardium.

The surgical specimen (Fig. 4) measured 8 by 4.5 by 2.5 cm. and consisted of pale brown fat, which was abnormally firm. Histologically, the findings were similar to those in Case 1 in that fat necrosis was present. Both the dissolution of fat and the fibrotic process were less extensive in this specimen than in Case 1. The fatty envelopes were filled with phagocytized fat, and a moderate inflammatory reaction was present. Serial block sections prepared with elastic van Gieson stain demonstrated vascular changes similar to those in Case 1, but of lesser degree.

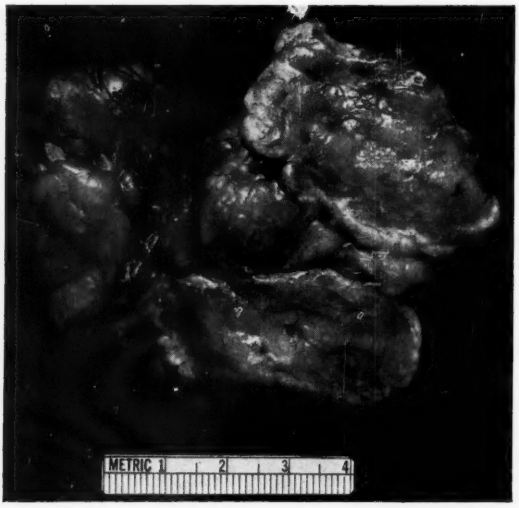

Fig. 4.—Case 2. Gross specimen of resected pericardial fat.

CASE 3.—A 47-year-old farmer's wife was referred to us on Aug. 8, 1955. Her health had been excellent until July 14, 1955, at which time she experienced a sudden dull constant pain in her left anterior chest. She was immediately hospitalized with a tentative diagnosis of myocardial infarction. The following day the pain had become more severe, was referred to the left shoulder and seemed somewhat aggravated by deep breathing. Chest roentgenograms taken at this time were interpreted as "pleuritis with effusion," but two attempts at thoracentesis yielded only a scanty amount of bloody fluid. Gradual abatement of pain occurred during nine days of hospitalization, and she had been asymptomatic for several days on admission to the Clinic. Her past medical history was not significant, and she had not had a chest roentgenogram prior to her present illness.

The only remarkable finding on physical examination was an extreme degree of obesity. She weighed 215 pounds and was only 62 inches tall.

Routine laboratory studies, including an electrocardiogram, were within the normal range, except for a leukocyte count of 10,900 per cubic millimeter with a normal differential count. Posteroanterior and lateral roentgenograms of the chest (Fig. 5) demonstrated an elevated left hemidiaphragm with an overlying mass in the region of the interlobar fissure. Motion of the posterior portion of the left hemidiaphragm was demonstrated by fluoroscopy, but its anterior portion and the lesion both appeared fixed.

Localized pleuritis with effusion, or the residual of a pulmonary embolism, seemed to be the most likely diagnosis at that time. In view of the patient's sex and recent acute

history, primary carcinoma was considered to be a most unlikely possibility. After a frank discussion with both the patient and her husband, an observation period of one month was advised.

Readmission roentgenograms on Sept. 9, 1955, demonstrated no appreciable change in the lesion. Thoracotomy was then recommended and on Sept. 14, 1955, the left lung

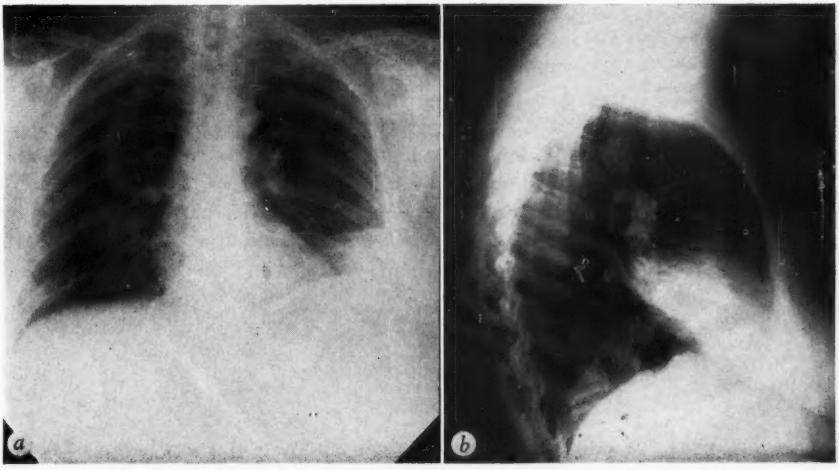

Fig. 5.—Case 3. *a*, Posteroanterior view, showing opacity due to fat necrosis overlying the elevated left hemidiaphragm. *b*, Lateral view, showing lesion in the area of the interlobar fissure and overlain by the base of the heart.

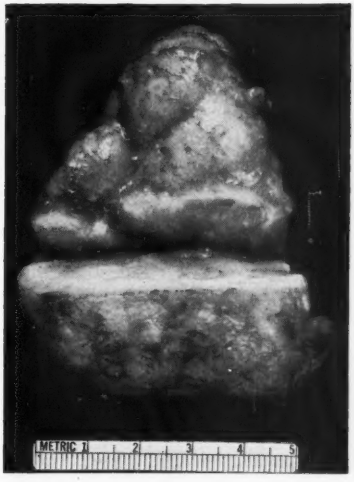

Fig. 6.—Case 3. Surgically resected specimen of pericardial fat. The fat is bulkier and firmer than normal.

was exposed through the bed of the sixth rib. No free fluid was encountered, and the pleural space was free except in the region of the diaphragm, where edematous adhesions were encountered. A firm, ovoid mass could be palpated low in the interlobar fissure.

A moderate degree of inflammatory reaction enveloped the mass, but the lobes were separated from it without damage. It was then recognized as a large necrotic fat pad and was removed from the parietal pericardium without difficulty.

The involved fat (Fig. 6) measured 7.4 by 6 by 2.5 cm. It was firm and again appeared browner than the surrounding fat. Microscopically it revealed the changes of fat necrosis and was not unlike the fatty masses in Cases 1 and 2. The inflammatory reaction was mild, with a moderate amount of fibrosis and a very extensive degree of phagocytosis of fat. Some of the small veins and arteries showed rather marked endarteritic changes, with considerable narrowing of the lumina. Proliferation of intimal cells and subintimal fibrosis were demonstrated.

COMMENT

The similarity of clinical findings in the foregoing patients is at once obvious. Onset of difficulty in each was heralded by acute low anterior chest pain, and thoracic roentgenograms demonstrated a mass close to the cardiac silhouette. All had a pleuritic component to their pain at some phase of their

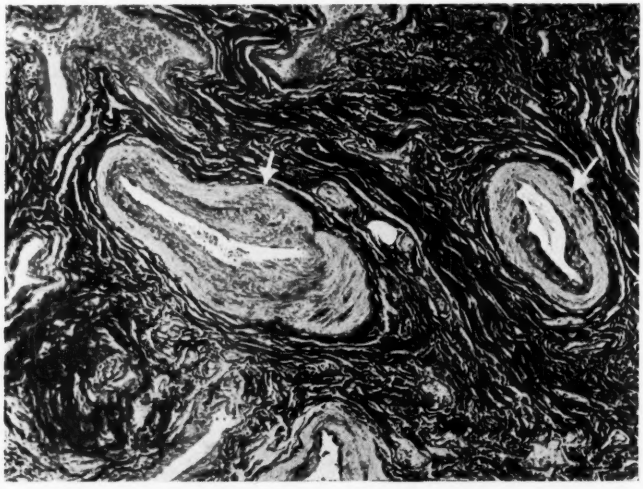

Fig. 7.—Section from a surgical specimen of epiploic appendicitis, showing subintimal fibrosis of the arterioles (arrows) (elastic van Gieson; ×90).

illness, and in 2 it was referred to the shoulder. In general, symptoms persisted, to become chronic, although intermittent in character. Each patient was quite obese, and we are inclined to believe that this is probably a prerequisite of their disease. In retrospect, then, these findings appear to be sufficiently constant to warrant clinical consideration of the correct diagnosis in any future case. Proper therapy would, however, indicate thoracotomy with resection of the diseased tissue. On surgical exposure, the true nature of these lesions may not be immediately evident, since they are enveloped by a moderately intense secondary inflammatory reaction. On cut surface, however, they are composed entirely of fat and are readily recognized as such.

In 2 of the patients reported in this paper the acute attack of anterior chest pain suggested the diagnosis of myocardial infarction. This diagnosis

was eliminated with the aid of serial electrocardiograms and thoracic roentgenograms. Many other disease entities might well be considered in the differential diagnosis of this condition; particularly, pulmonary infarction, localized pleural effusion, mesothelioma, pleuropericardial cyst and, as always, primary or metastatic carcinoma.

A consideration of the possible etiology of this entity appears justified. The tissue changes are not consistent with sepsis, and bacteriologic study of two specimens was unrewarding. The pedicle described in our first case appeared at operation to be slightly twisted. This immediately suggests compromise of the vasculature with resultant ischemia. A similar set of circumstances is well known to occur in the appendices epiploicae and in the omentum, but the end result, as would be anticipated, is hemorrhagic infarction and gangrene. Epiploic appendicitis of lesser magnitude does occur, but torsion has not been described in these cases. The vascular changes present in each of our specimens (see report of cases) were somewhat confusing to us. If this entity were of primary vascular origin, one would anticipate a uniform type of vessel abnormality rather than the array of changes which we observed. In an attempt to further evaluate this aspect of the problem, we studied two groups of cases. Eleven surgical specimens of fat necrosis of the breast and six surgically removed epiploic appendicitis specimens were prepared with elastic van Gieson stain. We were considerably surprised to find vessel changes varying from mild to severe in six of the breast and in four of the epiploic appendage specimens. The changes (Fig. 7) were quite similar to those found in our pericardial fat specimens. Apparently nonspecific vascular changes occur frequently in the presence of fat necrosis, and probably as a secondary phenomenon. We are, therefore, unable to offer a reasonable explanation of why fat necrosis should occur in this unusual location.

SUMMARY

1. Three surgically treated cases of fat necrosis involving parietal pericardial fat are reported.

2. These cases, to the best of our knowledge, represent a previously undescribed clinicopathologic entity.

3. All patients presented clinically with acute anterior chest pain, and their thoracic roentgenograms demonstrated a lesion in juxtaposition to the heart.

4. Histologically, the surgical specimens demonstrated the usual picture of fat necrosis and, in addition, abnormalities of some of the blood vessels.

5. These vascular changes were demonstrated in fat necrosis of other sites and are believed to be secondary in nature.

CHRONIC CONSTRICTIVE PERICARDITIS DUE TO ACTINOMYCES BOVIS

Report of a Case Treated by Pericardectomy

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ACTINOMYCES BOVIS is an uncommon cause of chronic constrictive pericarditis. This occurrence is not surprising in view of the pathologic behavior of this fungus which resembles that of the tubercle bacillus in certain respects. Of the 71 cases of actinomycosis of the heart and pericardium reported in the world literature since 1882, approximately 14 patients have presented the clinical syndrome of chronic cardiac constriction.

Prior to the advent of effective therapy, involvement of the heart or its membrane had occurred mainly as a late or terminal complication of a lethal infection. Consequently, the uncontrollable and diffuse nature of the infection in chronic obliterative pericarditis had uniformly precluded treatment by pericardectomy. More recently the beneficial action of the sulfonamides and penicillin has largely prevented the complication of pericardial and cardiac actinomycosis and permitted the safe undertaking of operative procedures in patients. This communication concerns a patient with chronic constrictive pericarditis due to *Actinomyces bovis* who is felt to represent the first documented instance in which pericardectomy has been carried out successfully.

CASE REPORT

Present Illness.—A 35-year-old Negro man, unit number A-72209, was admitted to University Hospital on Jan. 7, 1955, complaining of dyspnea, abdominal swelling, and ankle edema of four weeks' duration. He had been well until five months previously when he noted an area of tenderness on the lower left chest wall laterally. This area became indurated, softened centrally, and ruptured after several days. A small amount of drainage appeared which persisted for a few days following which the lesion gradually healed. He had no further symptoms until five weeks before admission when tenderness and induration reappeared in the same region. Within several days, this lesion ruptured and drained.

Scanty purulent drainage persisted and one week later (four weeks prior to admission) the patient developed severe dyspnea. He soon noticed abdominal swelling and ankle edema. He stated his heart felt "swollen." The dyspnea became increasingly severe, and orthopnea developed so that on three or four occasions he sat in a chair all night. Fever, night sweats, and frequent headaches were troublesome, and later he developed a cough which was productive of a small amount of mucoid sputum. The headache abated one week prior to admission, but the other symptoms persisted.

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Past History.—The past history did not contain additionally helpful data. There was no history of tuberculous infection or of contact with tuberculosis.

Physical Examination.—The patient was acutely ill with obvious respiratory distress. He was also emaciated. The temperature was 100.2° F. and pulse was 128 per minute. Respiratory rate was 26 per minute. The neck veins were markedly distended. Two ulcers were noted near the center of a roughly oval area of induration on the left lateral chest wall. The indurated area measured 8 cm. in greatest diameter and was near the midaxillary line overlying the left ninth, tenth, and eleventh ribs. Another area of induration (4 cm. in greatest diameter) was noted in the left midclavicular line overlying the fifth and sixth ribs. This lesion was tender but was not ulcerated.

There was dullness to percussion in the lower one-half of the left chest. In this region breath sounds were absent, although elsewhere coarse râles were heard in both lung fields. Respiratory excursion of the left hemithorax was markedy diminished and there was no visible or palpable evidence of cardiac pulsation in the left precordium. The heart sounds were distant and no murmur was heard. Blood pressure was 108/92 mm. Hg. A paradoxical pulse was present which encompassed the entire range of pulse pressure. The abdomen was ovoid, protuberant, and tense. Shifting dullness to percussion was noted and the liver edge was palpable 10 cm. below the right costal margin. Massive dependent edema was present which involved both lower extremities and extended up the trunk to the level of the heart.

Bacteriologic Data.—Typical "sulfur granules" were identified in purulent material draining from the left chest wall. Clubbing was seen at the periphery of these granules. Further examination of a crushed granule revealed numerous gram-positive branching filaments which resembled an actinomycete. The organism was not acid-fast with 3 per cent acid-alcohol decolorization. It was cultured on blood agar in a "Brewer anaerobic jar" where rough colonies resembling "bread crumbs" appeared after 4 days' incubation at 37° C. Examination of smears from the colonies revealed morphologic and staining characteristics similar to those just described. This organism was identified as *Actinomyces bovis.*

Laboratory Data.—Hemoglobin was 7.5 Gm. per 100 c.c.; hematocrit 25 per cent; red blood cells, 3.5 million per cubic millimeter; white blood cells, 5,400 per cubic millimeter; and differential count showed 87 per cent polymorphonuclear leukocytes. Urine specific gravity was 1.002. Tests for urine sugar and albumin were negative. Nonprotein nitrogen was 22.5 mg. per cent. Total protein was 5.78 Gm. per cent with 3.52 Gm. albumin, and 2.26 Gm. globulin.

Examination of the posteroanterior chest x-ray revealed marked enlargement of the cardiopericardial silhouette. Irregular areas of increased density were present in the left lower lung field extending from the level of the diaphragm to the anterior portion of the left fourth rib. The area of greatest density measured 1.5 by 3 cm. and was adjacent to the lateral chest wall corresponding in position to the larger region of induration described above. The right costophrenic angle was blunt. The electrocardiogram showed low QRS voltage with negative T waves in Leads I, II, III, V_3, and V_5 (Fig. 1). Venous pressure was 280 mm. of water and arm-to-tongue circulation time (Decholin) was 13 seconds. The hepatojugular reflex phenomenon was markedly positive.

Hospital Course.—Following admission the fever, restlessness, marked dyspnea, and orthopnea continued. He was given a low sodium diet (200 mg. per day) and advised to rest in bed. The day after admission the following therapy was instituted: intramuscular aqueous crystalline penicillin (4 million units daily), oral sulfadiazine (4 Gm. daily), and oral tetracycline (1 Gm. daily). Penicillin was changed to intramuscular aqueous procaine penicillin (1.2 million units daily) after three days of therapy. His temperature returned to normal five days after the initiation of treatment. By this time dyspnea and orthopnea decreased in severity, but hepatomegaly, ascites, and ankle edema persisted. Further radiographic studies, including roentgenkymography showed minimal to absent

cardiac pulsations. Pericardiocentesis was attempted from three different approaches but was unsuccessful. During the latter part of February, cardiac insufficiency was increasingly severe as evidenced by an increasing venous hypertension (maximum 380 mm. water) and marked prolongation of the circulation (maximum 43 seconds). Because of this, operative intervention was advised.

Operation.—Operative findings: An abscess, 3 cm. in diameter, containing minute particles was found in the soft tissues just anterior to the left fifth rib, 8 to 10 cm. from the costochondral junction. The heart, which was not enlarged, was encased in a thick fibrous capsule which markedly restricted its activity. The membrane measured 3 to 10 mm. in thickness. No exudate or fluid was encountered during decortication of the heart which was carried out with relative ease.

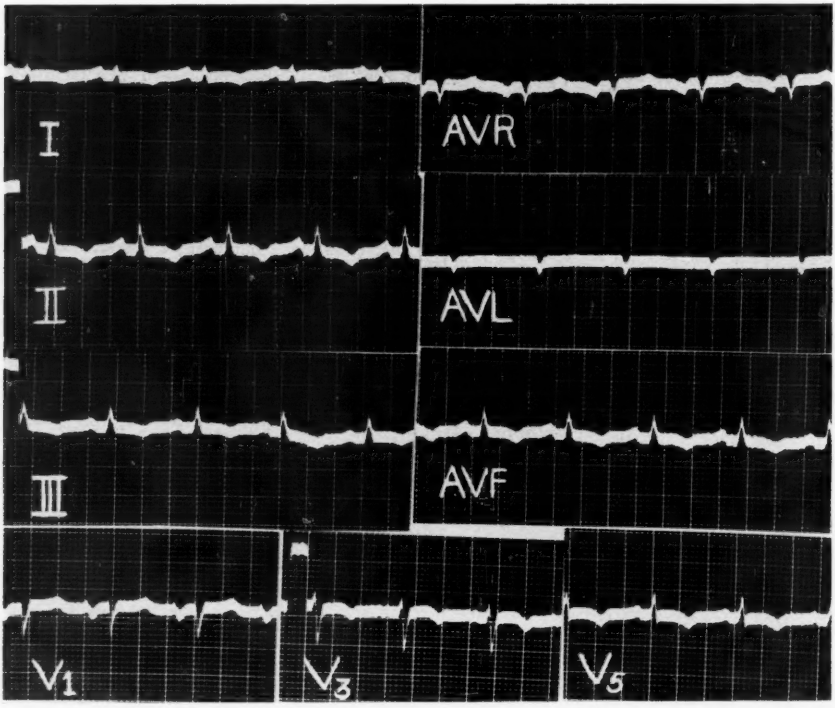

Fig. 1.—Electrocardiogram showing changes typical of pericarditis. (See text.)

Operative procedure: A transverse sternum-splitting incision was made in the fifth intercostal space. The upper end of the sternum was then split vertically 6 cm. The thickened membrane was removed from both ventricles anteriorly, down to the myocardium, carrying the excision 2.5 cm. posterior to the left phrenic nerve. Inferiorly, the entire diaphragmatic aspect of the heart was liberated and, superiorly, the atrioventricular groove on both sides was exposed. The heart action improved dramatically as the decortication progressed and became strong and vigorous after removal of the peel. The pulse rate and blood pressure were stable throughout the procedure. Closure of the wound was accomplished with silk sutures.

Pathologic data: Grossly, the pericardium was purplish-tan in color and varied from 3 to 10 mm. in thickness. Examination of material, obtained by sectioning the specimen, revealed gram-positive branching filaments, but cultures of this material failed to grow. Sections were prepared with hematoxylin-eosin, periodic acid-Schiff reagent, and Ziehl-Neelsen acid-fast stains.

Microscopic examination revealed a markedly thickened pericardium composed of fibrous tissue. A few sharply defined collections of polymorphonuclear leukocytes were seen which were considered typical micro-abscesses. One colony of *Actinomyces bovis* was found in such a lesion (Fig. 3). Numerous small blood vessels were present in the pericardium and, perivascularly, lymphocytic infiltration and scattered hemorrhages were noted. Some focal areas of round-cell infiltration were also present. No acid-fast organisms could be demonstrated. The final pathologic diagnosis was chronic constrictive pericarditis due to *Actinomyces bovis*.

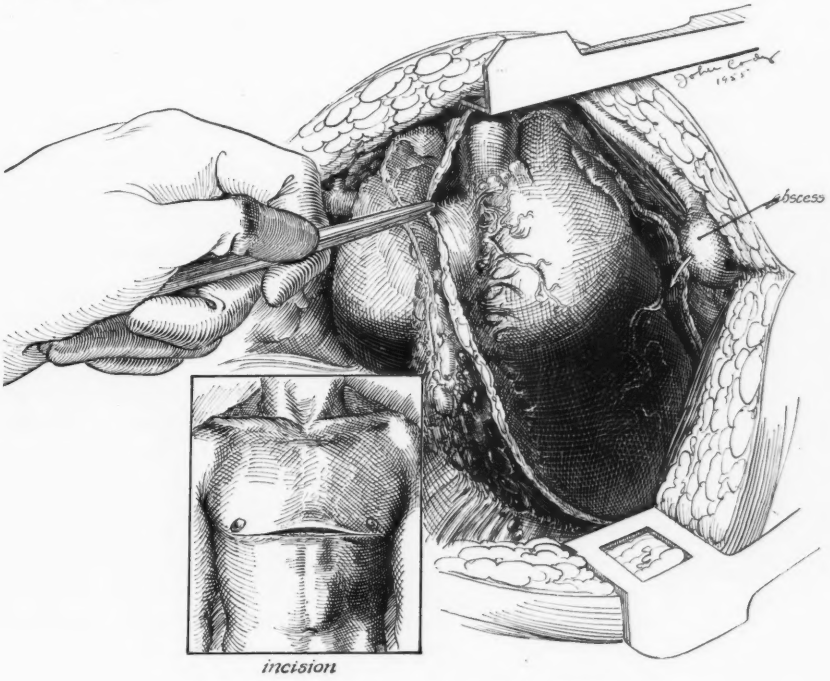

Fig. 2.—Artist's drawing of operative findings.

Postoperative course: His recovery following surgery was uneventful. The day after operation venous pressure was 146 mm. of water and arm-to-tongue (Decholin) circulation time was 19 seconds. He had a low-grade fever for six days although he reported subjective improvement. Subsequent determinations of venous pressure and circulation time were repeatedly within normal range. He was released from the hospital completely free of symptoms on March 26, 1955.

Following discharge he continued to receive intramuscular aqueous procaine penicillin (1.2 million units daily) and oral sulfadiazine (3 Gm. daily). He was free of symptoms when last seen, three months postoperatively. Examination did not reveal hepatomegaly or ankle edema. He was advised to continue medication for three additional months.

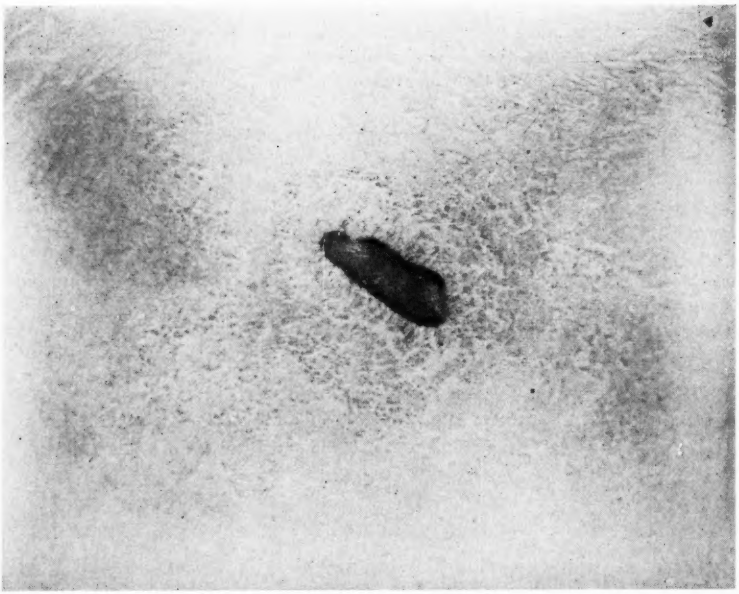

Fig. 3.—Photomicrograph of pericardium containing a typical "sulfur granule." Periodic acid-Schiff stain. (×400.)

DISCUSSION

The pathogenesis of actinomycotic pericarditis is discussed by Cornell and Shookhoff[1] who reviewed, in 1944, the clinical and pathologic findings in 68 patients, including 3 of their own with actinomycosis of the heart and/or pericardium collected from the world literature. The cases of 2 additional patients with this lesion have been appended to the end of their article, making a total of 70 patients.

The pathologic process observed at necropsy in 69 was similar to that noted in actinomycosis of other organs and tissues, characterized by a granulomatous reaction upon which are superimposed the features of acute and chronic suppuration. Microscopically, the lesions consist of minute abscesses surrounded by an actively proliferating connective tissue in which are scattered polymorphonuclear leukocytes, epithelioid cells, and numerous capillaries.

The pericardium was found to be most commonly involved by direct spread from a contiguous focus, most frequently in the lungs. Occasionally the pericarditis was a sequela of active infection within the myocardium which in turn had resulted from blood stream infection. Forty-one patients of the collected group studied by the authors fell into the former category, although in 12 patients the organism could not be demonstrated in the pericardial tissue. However, in each of the latter instances, a focus of actinomycosis was proved to be present adjacent to the heart. In 18 of 38 cases in which sufficient data were available the pericardial sac was completely obliterated

by actinomycotic granulation tissue. In those remaining, the changes ranged from mild inflammation confined to the parietal pericardium to a more severe fibrinopurulent process. In one patient, 750 c.c. of pus was recovered. In 20 of the 29 patients with proved pericarditis, invasion of the myocardium had occurred, leading to the formation of multiple abscesses with frequent extension of the process to the endocardium. At times the granulomatous masses actually projected into the cardiac chamber with perforation of the endocardium and pyemia in 6 patients.

Cornell and Shookhoff[1] noted that only 23 of 68 patients were reported to have manifested clinical evidence of disease of the heart or its membranes. However, the lack of data did not permit an accurate definition of the clinical picture in a significant number of the patients. The patients reported by Gose[2] and Lidbeck,[3] both of whom have been mentioned but not reviewed by Cornell and Shookhoff, were also shown to have chronic constrictive pericarditis. The syndrome of chronic constrictive pericarditis was absent in the others with demonstrable generalized obliterative pericarditis at necropsy. That an adherent pericardium is not necessarily synonymous with clinical cardiac constriction has been borne out by the study of Sprague, Burch, and White.[4] Their review of 43 patients with adherent pericardium among 1,900 autopsies at the Massachusetts General Hospital failed to disclose a single example of clinical constrictive pericarditis.

In the ten years since the report of Cornell and Shookhoff, no additional patients with chronic constrictive pericarditis due to *Actinomyces bovis* have been recorded in the literature. Zoeckler[5] has reported a patient with actinomycotic pericarditis in whom the chief clinical manifestation was the presence of a pericardial friction rub. Treatment with penicillin and Aureomycin resulted in complete recovery without sequelae. The rare occurrence of cardiac or pericardial actinomycosis during the past decade can undoubtedly be attributed to the efficacy of the antibiotic drugs in eradicating this infection.

The term "actinomycosis" is considered by Conant and Rosebury,[6] and others,[7, 8] as referring specifically to infections caused by *Actinomyces bovis*. Publications which do not conform to this terminology have not been considered in the present report. In this connection, it has not been possible to determine how many of the early reports dealt with infections caused by species other than *Actinomyces bovis*. The colony of organisms seen in Fig. 3 was not observed on routine histologic examination, but was discovered only after a large number of microscopic sections had been examined. This fact points out that actinomycotic granules might be easily overlooked in the case of healing pericarditis. Attempts to culture the organism at the time of surgery were unsuccessful although its staining characteristics were similar to those observed before treatment.

The role of surgery in diffuse adherent pericarditis due to the ray fungus has been a singularly insignificant one, a fact attributed to the ineffective control of the infection prior to the availability of present day therapy. As far as it can be ascertained from the available literature, pericardial decortication has been attempted only once prior to that of our patient. He was a

53-year-old white man, reported by Gose in 1942, who developed the characteristic picture of chronic constrictive pericarditis while he was under treatment for an undiagnosed infectious process in the right lower lobe. His course was extremely septic and progressively downhill. Pericardectomy was recommended for relief of his cardiac symptoms despite the continuing deterioration of the patient. At thoracotomy, the surgeon discovered an inflamed and thickened pericardium, and upon excising a portion of the parietal pericardium overlying the left anterior atrioventricular region, uncovered a large abscess. The operation was terminated at this point. The patient died on the day following surgery. Necropsy revealed a greatly thickened and indurated pericardium with sinuses and obliteration of the sac except for the previously described abscess. The underlying myocardium was not involved. Actinomyces were isolated in the exudate from the pericardium and from the operative incision, but were not cultured. The source of the pericarditis was traced to an abscess in the left lung.

The patient reported by Bigland and Sergeant,[9] in 1923, is the sole survivor in the collected series prior to Zoeckler's patient and deserves brief comment. This 22-year-old white man developed a massive purulent pericardial effusion due to *Actinomyces bovis*. Pericardiostomy, performed as a desperate measure, saved his life. He had been treated initially for postpneumonic empyema of the right pleural cavity by a rib resection but failed to improve satisfactorily. His dyspnea became ominously intense. A teleoroentgenogram of the chest revealed opacification of the left lung to the level of the sixth rib. After a pericardiocentesis was unsuccessful, incision into the pericardium yielded 25 ounces of a seropurulent fluid. The pericardial surface was shaggy. The patient recovered after a stormy convalescence without the sequela of chronic constrictive pericarditis. Attempts to demonstrate organisms from the original fluid from both the empyema cavity and the pericardial sac failed, but Actinomyces were later isolated in the drainage from the chest cavity.

The clinical problems and gross pathologic findings in our patient did not differ essentially from those frequently seen in patients with tuberculous chronic constrictive pericarditis. Although the surgical experience in actinomycotic pericarditis is meager, the principles commonly advocated in the surgical management of tuberculous constrictive pericarditis are equally applicable. Although the transverse sternum-splitting approach, as utilized by Johnson and Kirby,[10] and others, gave excellent exposure of the heart, the placement of the incision through the site of the healed sinus tract resulted in the inadvertent opening of an abscess in the chest wall. Fortunately, this did not lead to infection of the wound or other harmful complications. The alternative and better incision in this case would have been a medium sternotomy to circumvent completely the region of the abscess. The outcome in this patient would indicate that pericardial decortication can be safely performed relatively soon after subsidence of an active infection.

SUMMARY

1. A patient is presented with chronic constrictive pericarditis caused by *Actinomyces bovis*.

2. The principles of therapeutic management were essentially those followed in the treatment of constrictive pericarditis of tuberculous etiology.

3. This patient is thought to represent the first reported instance of successful pericardectomy in actinomycotic constrictive pericarditis.

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ESOPHAGOJEJUNOGASTROSTOMY

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THE performing of esophagojejunostomy by Roux loop, after radical total gastrectomy for malignant disease of the stomach, provided enough technical experience for the method to be applied to intestinal reconstruction after the removal of simple peptic strictures of the esophagus. A regular survey of those patients who survived for years after excision of a carcinoma showed that, with occasional medical care, their weight, strength, and capacity for work were much better than had been anticipated; some of them are still working and taking a normal diet five to eight years after operation. When esophagojejunostomy was used for benign lesions of the esophagus, it was usually unnecessary to resect the stomach. This was, therefore, closed at its upper end and left in place as a blind appendage to the alimentary canal. Food then passed from the esophagus into the jejunum where it travelled for twelve to eighteen inches before it met the bile and pancreatic juice and such gastric juice as was secreted. The patients with benign lesions form an interesting group for study, for they should have a long expectation of life.

Groups of patients, 26 who have had radical resections for malignant disease and survived more than 3 years, 10 with total resections for benign lesions (some of them thought to be malignant at operation), and 42 patients who had had esophagojejunostomies for peptic stenosis of the esophagus (in most of whom the stomach was left in place), have formed a modest basis on which to assess the effects of such drastic alterations to the alimentary tract on nutrition, strength, and habits of life. The patients were mostly past middle age and their progress over the years will be the subject of a further report. The results have been generally good, some have been excellent and some very poor, a description that might be applied with equal validity to almost any operation on the stomach that alters the design of nature. However encouraging some of these results might be in middle-aged and elderly people, they hardly seemed to justify doing the same operation on a small child. The idea of by-passing the stomach and duodenum in a child 4 or 5 years old with its special needs for growth, development, maturation, and reproduction was inadmissible, and yet these were the patients who seemed to be most urgently in need of help. Some surgeons have tackled the problem by performing long esophageal resections and high mediastinal esophagogastrostomy. This operation has been immediately effective in relieving the dysphagia, but it will be some time before the metabolic results become apparent. Some strictures

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have recurred and there is ever present the danger of the inhalation of stomach contents into the lungs during sleep, but this method of treatment is undoubtedly a great advance on anything that has been done before.

In 1953, Brain[1] published some results on fat absorption after various gastric operations, and on these findings recommended the excision of esophageal peptic strictures, the reduction of the stomach into the abdomen and restoration of continuity by an isolated intestinal loop within the mediastinum and abdomen. This was a modern adaptation within the mediastinum of what Roux[2] had originally performed beneath the skin of the chest wall. In the same paper, Brain gave an account of the one patient on whom he had performed the operation successfully in November, 1951, and he now reports in a personal communication that he has done three more. If this operation could be done safely it would seem to provide a satisfactory answer to the problem in children and might even be more generally applicable. The possible objections to the operation are first that it involves many anastomoses and that there are therefore many opportunities for technical mistakes, second that ulceration might occur at the jejunogastric junction, and third that there might be difficulty in vomiting should the need arise. The first of these listed dangers inevitably persists as the following records will show. The earliest patient operated upon in the series died as a result of technical faults, and the description of many other mistakes that have been made and then corrected may be a help to other surgeons working in this field. No gastrojejunal ulceration has yet been observed, and one child who ate too much rich food vomited successfully.

The technique of esophagojejunogastrostomy is here described and some details of the 11 patients upon whom it has been performed are recorded.

Operation.—A left thoraco-abdominal incision is made through the eighth space and the diaphragm is split back toward, but not into, the hiatus. The edges of the diaphragm are conveniently retracted by being sutured to the edges of the costal incision. The gastrosplenic omentum is divided, the vasa brevia being ligatured, so that the fundus of the stomach and the left half of the greater curvature are free. The stomach is rotated forward and the vessels at the upper end of the lesser curvature secured and divided from the back. The stomach is divided just below the cardia and the two ends sutured and infolded. The cardia is drawn up into the mediastinum and the diseased part of the esophagus is dissected free with a length of normal esophagus above, to give both space and mobility for an easy anastomosis. The vagus nerves may be dissected free from the wall of the esophagus in the hope of preserving some of their fibers, but it usually happens that most of them are divided before the operation is completed. The esophagus is then allowed to "lie fallow" in the mediastinum, while a Roux loop, long enough to reach the normal part of the esophagus without tension, is fashioned. The details of construction of a Roux loop have already been described (Allison and Da Silva[3]) and do not differ materially from that in the original paper by Roux,[2] himself (1907). The upper end of the loop is closed by inversion and suture.

At this point it is useful to perform a pyloromyotomy, for the stomach is still free and a choice can therefore be made between the anterior and posterior surface of the pylorus, depending on which is the more accessible. Care is needed if the muscle fibers of the pylorus are to be completely divided without injury to the duodenal mucosa, for, since the pylorus projects into the duodenum, the mucosa of the latter comes to overlay the deepest fibers of the muscle and is easily opened (by mistake) before all the muscle has been separated. From the experience so far gained, the performance of pyloromyotomy is considered to be a useful safeguard against gastric delay and distention in the weeks following operation when the peristalsis of the stomach is weakened by vagal paralysis.

A hole is next made in the transverse mesocolon, as far back as possible on the posterior abdominal wall so that no ridge occurs here when the transverse colon is drawn down. Through this hole, the Roux loop is threaded and passed up behind the stomach in the now widely opened lesser sac of peritoneum, through the hiatus and into the mediastinum. The hiatus may be enlarged a little by stretching its walls so that the loop is not held tightly. The subterminal part of the loop is joined to the musculofascial layer of the esophagus above the stricture, the diseased part of the esophagus excised, and the anastomosis completed. The loop below the diaphragm is so arranged that it passes over to the left behind the fundus of the stomach and reaches the greater curvature in the region of the gastrosplenic omentum, and a point is selected on the loop that can be anastomosed to the posterior surface of the stomach without tension or kinking. The intestine is then divided at this chosen point. One or two of the arteriae rectae of the upper segment are divided in order to free the circumference of the intestine and so facilitate the anastomosis to the stomach. The intestine below the level of the section must then be freed so that it can be drawn down and reunited to the small length of jejunum attached to the duodenum below the transverse mesocolon. This may mean the division of six to ten arteriae rectae and even the removal of a short segment of the intestine itself. The upper segment of the loop is anastomosed end-to-side to the posterior aspect of the stomach. For this purpose, it is probably wise to cut the end of the intestine obliquely or "on the bevel" so that it is not made to kink by the necessity of turning abruptly forward to join the stomach. The lower segment is joined to that piece of jejunum left in continuity with the duodenum by as long a side-to-side anastomosis as possible. The hole in the transverse mesocolon, which now only transmits the mesentery carrying the blood vessels of the isolated loop, is closed above the duodenojejunal flexure and above the entero-anastomosis. The stomach is stitched back to the diaphragm to remake the lesser sac of peritoneum and a gastrostomy is performed in its anterior surface. After this operation, patients always swallow air and, whereas, in the absence of a pyloromyotomy the stomach becomes inflated, in its presence, the air passes on into the intestines and causes generalized distention. The performance of a gastrostomy is not for the purpose of feeding but to allow the escape of gas,

and it is therefore left draining into a bottle for the first few days after operation. Apart from allowing for the escape of gas it is also very useful for determining the state of intestinal and gastric motility, because when the patient is fed by mouth the time of arrival of food in the stomach can be observed, and, by closing the tube for a short time after a meal and then opening it again, the rate of stomach-emptying can be estimated and so the timing of feeds controlled. Another advantage of a gastrostomy is that the patient can be given drinks as soon as he recovers from his anesthetic. The effect of being able to drink by mouth is a great relief and encouragement to a patient, even if the fluid escapes through a gastrostomy drain. His fluid requirements in these early days are maintained by intravenous infusion.

The following case histories are given, not only to illustrate the ultimate efficiency of the operation but to describe the many mistakes that have been made.

CASE REPORTS

CASE 1.—P. B., a male child, was aged 2½ years when first admitted to the hospital, had vomited since birth and had never been able to take solid food. No tumor had ever been felt at the pylorus. Radiography showed persistent narrowing of the junction of the middle and lower thirds of the esophagus and retention of barium in the stomach five hours after ingestion. Esophagoscopy confirmed the presence of a stricture with apparent periesophageal induration at a level estimated to be just below the bifurcation of the trachea. Over the succeeding ten years the child was esophagoscoped and gently dilated ten times. By then the esophagus was stenosed over a distance of 7 cm., the stomach was large with poor peristalsis, but no abnormality could be detected in the pylorus or duodenum.

Operation (P. R. A.) was performed on Dec. 8, 1953, as already described, except that no pyloromyotomy was done. There was no evidence of ulcer or scar at the pylorus. Eight arteriae rectae were divided and 2.5 cm. of intestine was resected below the level of the jejunogastric anastomosis. An end-to-end entero-anastomosis was performed below the transverse mesocolon. The boy developed obstruction at this anastomosis and was operated upon twice for its relief, but the loop in the chest became distended and perforated to form an empyema. During an operation for this last condition, he inhaled pus and barium and died shortly afterward of bronchopneumonia.

CASE 2.—B. M., a male child, was first admitted to the hospital at the age of 13 months because of vomiting since birth and inability to take solid food. No pyloric tumor could be felt. Radiography showed a stenosis of the distal part of the esophagus with sliding hiatal hernia (Fig. 1), a large stomach, and a deformity of the duodenum. Esophagoscopy confirmed the presence of a tight peptic stenosis. During the succeeding seven years the boy was esophagoscoped eight times.

Operation (P. R. A.) was performed on Feb. 17, 1953. The cardia was 2 cm. above the hiatus and the stenosis of the esophagus extended from here up to 2 cm. below the aortic arch. Resection and esophagojejunostomy were performed at the level of the aortic arch (Fig. 2). The loop was transected below and the end implanted into the posterior aspect of the stomach in the region of the cut vasa brevia (Fig. 3). Five arteriae rectae were divided and the remaining part of the loop turned down and anastomosed, end to end, to the segment of jejunum descending from the duodenum. Neither a gastrostomy nor a pyloromyotomy was performed. Three days after operation, the patient became very ill with abdominal cramps, distention of the abdomen, and dyspnea. The abdomen was opened and an enormously distended stomach was found to be filling the upper abdomen. It was decompressed slowly by the withdrawal of 3 pints of watery and rather bile-stained

fluid. The duodenum and the jejunum, for 10 cm. beyond the entero-anastomosis, were also distended. The obstruction was apparently caused by the kinking and adhesion of the intestine at this level. The adhesions were divided, the gut straightened, and a gastrostomy performed.

Two years later the boy was seen to have developed well, was eating "anything and everything," and had no complaints.

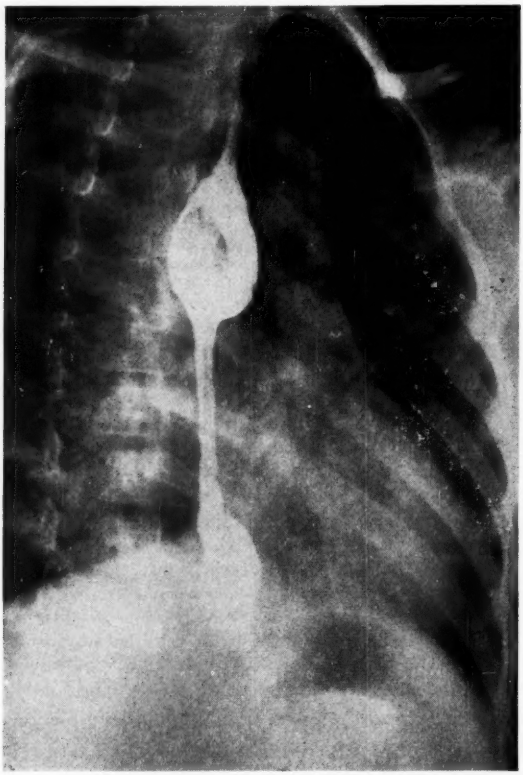


Fig. 1.—Case 2. Long peptic stenosis of esophagus with sliding hiatal hernia.

CASE 3.—A. P., a man aged 66 years, suffered for one year from dysphagia and epigastric pain. Radiography showed an irregular stenosis 5 cm. above the cardia and esophagoscopy confirmed that this was a simple peptic ulcer.

Operation (A. G. Morrow) was performed on May 14, 1953. This was carried out as described but no pyloromyotomy was done, and intestinal continuity was restored by end-to-end anastomosis. The loop between the esophagus and stomach was redundant and became kinked and dilated in the chest. In addition, there developed some narrowing of the esophagojejunal stoma. The wound was reopened about five weeks after the first operation, the anastomosis and the redundant loop were resected and a new anastomosis made.

The patient's progress was satisfactory and, when last seen, two years after operation, he was eating normally, had put on weight, had a normal blood count, and was free from symptoms. Barium passed through all segments of the alimentary canal normally.

CASE 4.—J. G., a man aged 34 years, had had vomiting since birth and dysphagia for solid food since the first time it was tried. He was underweight and underdeveloped, had never had a solid meal in his life, and had never been able to take part in "social" eating. Radiography showed a tight stricture with an ulcer crater or diverticulum at a level 5 cm. below the bifurcation of the trachea. Below this was a segment that might have been esophagus lined with gastric mucosa and then a sliding hiatal hernia. The upper segment of the esophagus was dilated and showed very vigorous peristalsis after swallowing. There was no abnormality at the pylorus. A tight stenosis, at 36 cm., was confirmed by esophagoscopy but no view was obtained beyond it.

Fig. 2.

Fig. 3.

Fig. 2.—Case 2. Roux loop anastomosed to esophagus at the level of the aortic arch after excision of peptic stenosis.

Fig. 3.—Case 2. The lower end of the isolated Roux loop anastomosed to posterior surface of the stomach in the region of the cut vasa brevia.

Operation (P. R. A.) was performed on Oct. 7, 1953. The vascular arcades of the small intestine were very bizarre so that the effective length of the Roux loop was small in relation to the length of jejunum composing the loop. The spleen was three times its normal size and was some impediment to the isolating and severing of the cardia. The esophagus, in the region of the stricture, had to be freed from the pericardium by knife dissection. The esophagojejunal anastomosis was made and eight arteriae rectae divided

at the level of the projected gastric stoma. Intestinal continuity was restored by end-to-end anastomosis, and a gastrostomy performed. Pyloromyotomy was not done. Three days after operation the patient became distressed, and malodorous heavily bile-stained fluid was aspirated from his stomach. Radiographs showed a high fluid level in the stomach and another in the duodenum. The anterior end of the incision was opened and obstruction was found to be caused by acute kinking at the entero-anastomosis. Side-to-side anastomosis was made just below the kink and the spur of the kink divided. After this second operation, the patient was collapsed and dyspneic and was found to have a tension pneumothorax on the left side. This was aspirated and recovery thereafter was without incident.

For some short time he was rather afraid of taking solid food but he soon overcame this, and as his confidence increased he started to eat "all that was put before him" without discomfort. Strength and appetite improved rapidly until he had to diet against putting on too much weight. One of the most notable benefits of operation was the patient's ability to dine with friends. This altered his whole outlook on life.

CASE 5.—E. B., a woman aged 47 years, was the only patient in this series for whom esophagojejunogastrostomy was done after the excision of a malignant lesion. The patient gave a long history of epigastric discomfort and belching for which she had taken alkalies. For six months she had had dysphagia and for a few weeks almost complete obstruction to solid food. She had lost 14 pounds weight. There were no abnormal physical signs. Radiography showed a stricture at the junction of the middle and lower thirds of the esophagus, and the top of this was seen, by esophagoscopy, to be at 32 cm. It was a squamous-cell carcinoma.

Operation (P. R. A.) was performed on Nov. 17, 1953. Some modification of the steps already described were adopted. A Roux loop was made long enough to reach the superior mediastinum. Instead of division of the vasa brevia, the upper part of the stomach down to the lower pole of the spleen on the greater curvature and halfway along the lesser curvature was removed with the spleen, body of the pancreas, and retroperitoneal tissues; the splenic and left gastric vessels being divided at their origin. This block of tissue with the fascia of the diaphragm was drawn up into the mediastinum and the esophagus dissected free, with its surrounding mediastinal tissue up to the aortic arch. Through the same skin and muscle incision, a further thoracotomy was made through the fifth space: two pairs of aortic intercostal arteries were divided and the arch of the aorta dissected free from the esophagus. The spleen was removed from the cardia so that the latter could be drawn up from beneath the arch of the aorta into the superior mediastinum and delivered from there into the pleural cavity. The Roux loop was threaded up through a hole in the transverse mesocolon, through the hiatus, beneath the aortic arch, and out into the left pleural cavity where it was stitched to the esophagus. The esophagus below, with the growth and the cardia, was removed and the esophagojejunostomy completed. The rest of the operation followed the lines laid down, eight arteriae rectae being divided, and the jejunal continuity restored by end-to-end anastomosis below the transverse mesocolon.

When assessed nineteen months later, the patient was eating four meals a day, had a good appetite, was maintaining her body weight and was free from symptoms. Dr. Johnstone reported: "barium swallow shows a satisfactory anastomosis at the level of the aortic arch. A little kinking of the jejunum is noted in its thoracic course but peristalsis is vigorous and effective. Barium passes through the hiatus and after a short course enters the stomach through a posterior stoma. Peristalsis of the stomach is only moderate."

CASE 6.—R. D., a boy who had vomited since birth, was first seen in the hospital at the age of 5 months. He was found at radiography and esophagoscopy to have an esophageal stenosis and sliding hiatal hernia. The stricture was dilated through the esophagoscope fifteen times during the next ten years. On frequent occasions, radiography demonstrated a large stomach with poor and ineffective peristalsis and pylorospasm, but at other times the stomach appeared normal.

Operation (P. R. A.) was performed on Feb. 9, 1954. Esophagus lined by gastric mucosa was found between the stricture and the herniated stomach. The resection and anastomosis were carried out as described, pyloromyotomy and gastrostomy were done, and intestinal continuity was restored by a large side-to-side anastomosis.

Recovery was without incident, and eighteen months later the patient was eating everything that was put before him, was developing rapidly, and was well in every way.

CASE 7.—R. C., a woman aged 54 years, had had dysphagia for solid food for five years. Radiography and esophagoscopy showed that she had a peptic stenosis of the esophagus with a sliding hiatal hernia.

Operation (P. R. A.) was performed on Aug. 7, 1955. This was just as described. Pyloromyotomy, gastrostomy, and side-to-side entero-anastomosis were used. Recovery was uneventful and the patient has been completely free from symptoms and eating a normal diet to the present time.

CASE 8.—J. G., a woman of 37 years, had vomited since the eighth day of life and had never been able to eat solid food. She had had various forms of medical and psychologic treatment and many years of bougienage. The esophagus had been perforated by a bougie with a resulting right hemothorax and at that time a gastrostomy was done. Some years after this, the peptic stenosis of the esophagus had been resected, esophagogastrostomy performed, and the gastrostomy allowed to heal. A further peptic stenosis had developed, and complete collapse of the right lung. Two separate plastic operations had been done to open up the stenosis but these had given only very temporary relief and a gastrostomy had to be remade to save the patient's life. Esophagoscopy showed a complicated and ulcerated stricture with excessive granulation tissue at 32 cm.

Operation (P. R. A.) was performed on Aug. 16, 1955. The old scars were excised. The lesser sac was opened and a pyloromyotomy performed on the posterior aspect to avoid disturbing the gastrostomy. The esophagogastrostomy was freed and resected, the stomach closed and returned to the abdomen. The rest of the operation was as described. In the postoperative period there was some obstruction by kinking of the loop at the jejunogastric junction. The kink was obliterated by extending the anastomosis upward to include the kink, and after that the patient's progress was uneventful.

She has been eating normally and gaining weight rapidly in the eight months since operation.

CASE 9.—P. C., a male child, was seen at the age of 6 months because of regurgitation of feedings. He was found to have a sliding hernia with esophagitis and some stenosis. Two attempts were made to reduce the hernia in the hope that the stenosis and ulceration would heal, but both were unsuccessful. During the following four years, the patient required esophagoscopic dilatation six times.

Operation (G. H. W.) was performed on Oct. 25, 1955, as already described. The intestine was reunited by side-to-side anastomosis. This boy developed purulent sputum with some pulmonary collapse and a draining sinus in the chest wall, but a barium swallow, five months afterward, showed that all the anastomoses were working well. He was taking a normal diet but his general development was still delayed by the chest infection.

CASE 10.—B. J., a man aged 31 years, had complained of dysphagia for fifteen years with notable deterioration in the four months previous to being seen. Radiography and esophagoscopy demonstrated a short, narrow peptic stricture, 8 cm. above the diaphragm, and a sliding hiatal hernia.

Operation (G. H. W.) was performed on Nov. 22, 1955. The steps were as described, the pyloromyotomy being done on the posterior surface. Recovery and convalescence were uneventful and during the short time since operation the patient has been eating normal meals without discomfort and has been gaining weight.

CASE 11.—F. H., a boy of 16 years, had been under observation for vomiting and dysphagia since the age of 1½ years, and had had esophagoscopic dilatations six times with

many long intervals of good progress. He had a short peptic stenosis with a large sliding hiatal hernia.

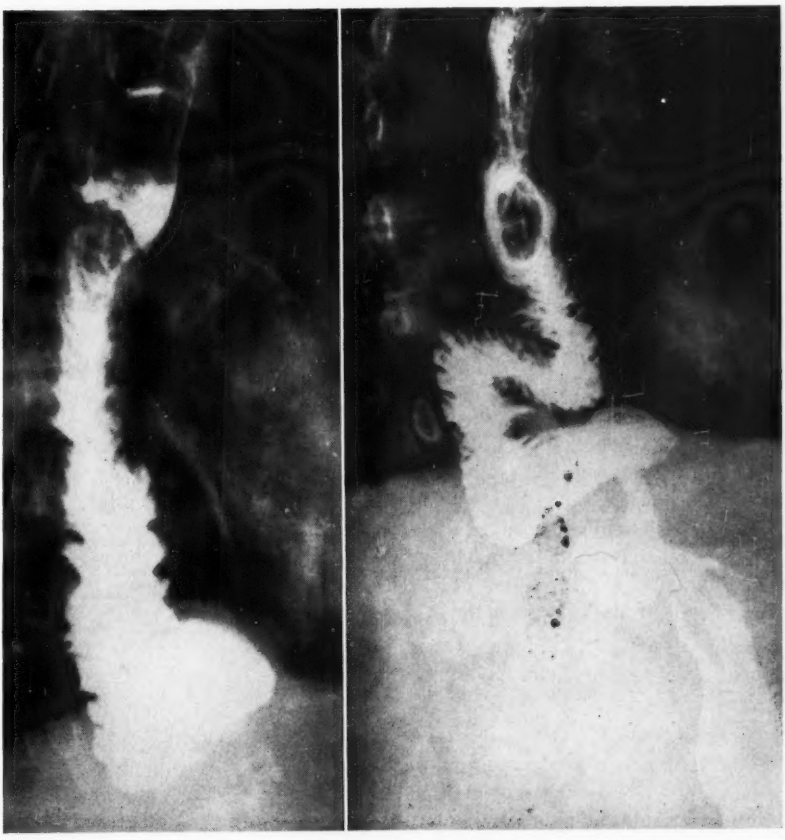
Operation (G. H. W.) was performed on Feb. 23, 1956. This was as described except that no pyloromyotomy was performed and intestinal continuity was achieved by end-to-end anastomosis. This junction became kinked and obstructed in the postoperative period and had to be converted into a large side-to-side anastomosis after which recovery was uneventful. A barium meal, one month after operation, showed uninterrupted progress of the medium through all segments of the gut and the patient is now eating well and is free from symptoms.

DISCUSSION

Large esophageal defects created partly by disease and partly by surgical excision can be bridged by a length of jejunum, after a plastic operation on the mesentery according to the method of Roux, whose original idea of connecting the lower end of the loop to the stomach is applicable to reconstruction within the mediastinum, and would appear a priori to be the method least open to objection on metabolic grounds. The metabolism of the patients treated so far can be estimated by their appetite, their weight, their feeling of well-being and, in children, their development. On these criteria, the operation has fully justified itself and is superior to any other known method of reconstruction. Only by trial and waiting will it be learned whether gastrojejunal ulceration will prove to be an important complication. Although this did occur when the loop was used subcutaneously and was the reason why many surgeons abandoned the operation, the same will not necessarily occur when the mediastinal route is used, for here the point of entry of the jejunum into the stomach is at the top, in the region of the fundus, where the drainage is of mucus, and downward, rather than of acid pepsin, upward. The subcutaneous operation involves a loop of jejunum passing upward into the most dependent part of the stomach so that the jejunal mucosa must be constantly bathed by digestive juice. The occurrence of peptic digestion of the esophagus where this enters the top of the stomach in hiatal hernia is not comparable with the jejunum's entering the fundus of the stomach, for ulceration in the former circumstance is dependent upon the differential pressures in chest and abdomen which aspirate the juices into the esophagus, whereas in the operation of esophagojejunogastrostomy, the lower 10 to 15 cm. of the jejunum and its junction with the stomach are all under the same pressure in the abdomen. The loop is passed over the back of the fundus so that, as the stomach distends, it compresses the loop and prevents reflux. If the loop were to be brought straight through the hiatus and into the nearest part of the stomach, the chances of reflux acid ulceration would be greatly increased. This "valve action" might well be a menace if it were to prevent vomiting but, as already reported, one of the patients has vomited successfully. It would be interesting to know how he managed this.

The main objection to the operation is the tediousness of the techniques and the consequent opportunities for mistakes. From the errors so far committed, some advice can be tentatively offered; the Roux loop should be as straight as may be, which means that the length of the intestine should be

as nearly equal as is possible to the length of the mesentery supplying it with blood vessels (Fig. 4, *A* and *B*). This is not always feasible, and in such case much can be done to improve a curled loop if the steps previously recommended are adopted (Allison, P. R. and Da Silva, L. T., 1953). If the hiatus is small it should be enlarged, but if the loop does not pass through it without kinking,



A. *B.*

Fig. 4.—*A*, A good Roux loop lying straight in the mediastinum. After division of the vascular radicals the mesentery was as long as the gut.

B, A less favorable Roux loop. An arcade was deficient at one point so that vessels had to be divided far back toward the abdominal wall. This left a curve that could not be straightened.

it should be closed and a new hole made to suit the position of the intestine, for a sagging loop in the pleural cavity may cause stagnation or even obstruction; the jejunum should be bevelled to meet the back wall of the stomach without kinking; the lesser sac should be closed by stitching the stomach back to the diaphragm to prevent intraperitoneal herniation, that part

of the loop below the gastric anastomosis may need to be trimmed to bring it down to lie snugly on the patients' right side of the duodenojejunal flexure; this part of the loop should be joined by a large side-to-side anastomosis to those few inches of jejunum still in continuity with the duodenum, for an end-to-end junction is too liable to become obstructed by slight rotation, kinking, or adhesion formation; the patency of this junction is vital for the other anastomoses. Pyloromyotomy is advised so that the weak peristaltic waves of the stomach are not obstructed by a pylorus in spasm from vagotomy. A temporary gastrostomy is of great value for letting out the quantities of air that the patient swallows. The gastrostomy tube should be left in for at least ten days until a safe track of granulations has formed, but if the stomach is emptying freely and aerophagy has ceased it may remain plugged for the last five days before removal. If for any reason the abdomen has to be reopened soon after operation, great care is needed to avoid inhalation of intestinal contents; a radiograph of the chest should be taken before the patient returns to the ward, for air entering the abdomen may be aspirated into the pleura during operation, or forced up when the abdomen is closed, and so cause severe respiratory embarrassment.

SUMMARY

1. Esophageal replacement by an isolated loop of jejunum in the mediastinum is described.

2. The technique of esophagojejunogastrostomy and its metabolic advantages are discussed. It is considered to be particularly applicable to the treatment of esophageal stenosis in children and in women, who do not tolerate exclusion of the stomach as well as men do. Where the more complicated operation is not contraindicated, however, it may become the routine operation for all patients with long, benign stenoses.

3. Combined with adequate lymphatic dissection, the operation may be applicable to patients who have carcinoma of the esophagus not involving the stomach.

4. Brief case histories are given of 11 patients treated in this way, with one death. There were many complications due to technical faults, and these are described. After the complications had been overcome, the health of the 10 living patients remains excellent.

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INCOMPETENCE OF THE CARDIA

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REFLUX of gastric juice in the esophagus causes troublesome symptoms. Especially after meals, the patients have a feeling of discomfort in the epigastrium or behind the lower part of the sternum. They complain of heartburn and, occasionally, sour gastric content may come up into the mouth. In cases of pronounced esophagitis, the patients have a burning pain behind the sternum which is more intense after meals. It is characteristic that the pains are felt in certain positions; when the patients lie flat on their backs or when they bend forward, positions which facilitate regurgitation.

The mucous lining of the esophagus exhibits pathologic alterations, from a slight inflammatory condition to ulcerations with fibrosis and strictures. These alterations are most commonly located in the lower part of the esophagus.

Hiatus hernia is the most frequent cause of reflux of gastric juice. The cardiac end of the stomach slides up into the thoracic cavity, and then the cardia lies above the diaphragm with the result that free regurgitation of gastric juice occurs (Fig. 1).

In rare cases, there may be typical regurgitation symptoms and the same pathologic alterations in the esophagus, although no hiatus hernia can be demonstrated radiologically.

In such cases there is an incompetent cardia. It is believed that the cause is due chiefly to an abnormal conjunction of the esophagus with the stomach, as shown in Fig. 2. The normal esophagogastric angle is here straightened out so that the esophagus empties into the stomach at its highest point. Allison[1] has shown that when the stomach and esophagus are taken from a body and placed in normal relation to each other, water which is pumped into the pylorus will stop when it reaches the cardiac. If the parts are placed in such a manner that the esophagus empties into the top of the stomach, the cardia will be insufficient.

In normal dogs, the gastric contents cannot be emptied into the esophagus as long as they lie in normal relation to each other, but if the fundus is removed, regurgitation will occur.

Barret[2] demonstrated regurgitation in normal individuals when he depressed the fundus during operation, and it is believed that it is depression of

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the diaphragm with the fundus, which facilitates vomiting in human beings with normal cardia function.

At the Surgical Dept. A. Rikshospitalet, a case of cardia incompetence has been treated.

Fig. 1.—X-ray of sliding hernia.

CASE REPORT

Case history: The patient was a 47-year-old man who had had gnawing pains behind the lower part of the sternum, radiating down into the stomach for twenty years, and he had also suffered from regurgitation. He had three times previously, in 1935, 1947, and 1953, been taken into hospital for observation for these symptoms, but examination including x-ray of the stomach revealed no explanation. In addition to these symptoms, he had had difficulty in swallowing during the past few years and had the feeling that food stopped behind the lower part of the sternum. He was admitted to the department under the diagnosis of tumor of the esophagus, as x-ray examination had revealed an irregular contour in the lower part of the esophagus.

Present condition: He was in good general health. General examination revealed nothing pathologic. Blood was normal. Feces, benzidine five seconds. The Ewald test demonstrated acidity to be 15/40. X-ray of esophagus, stomach, and duodenum showed an irregular contour in the lower part of the esophagus with a small niche, but no tumor infiltration. There was marked regurgitation of the stomach contents. The stomach had an atypical position, lying horizontally, with the greater part of it in the right side of the abdomen. The junction of the esophagus with the stomach was pathologic, as shown in Figs. 2 and 3. The radiologists' conclusion was esophagitis and insufficiency of the cardia.

Esophagoscopy revealed an inflamed thick mucous membrane in the lower part of the esophagus and severe regurgitation, but no signs of ulceration.

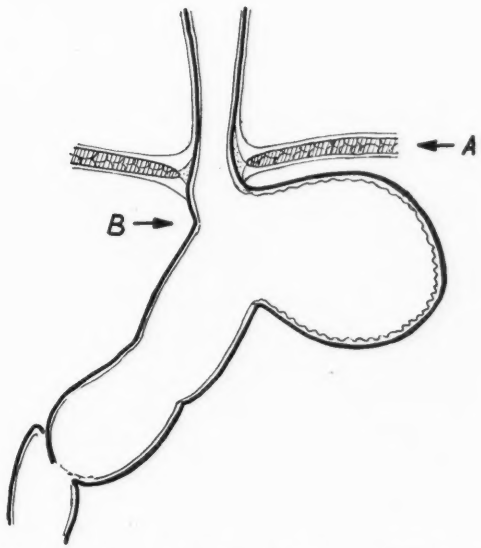

Fig. 2.—*A*, Diaphragm. *B*, Abnormal right-angled conjunction of the esophagus with the stomach.

Fig. 3.—X-ray corresponding to the drawing on Fig. 2.

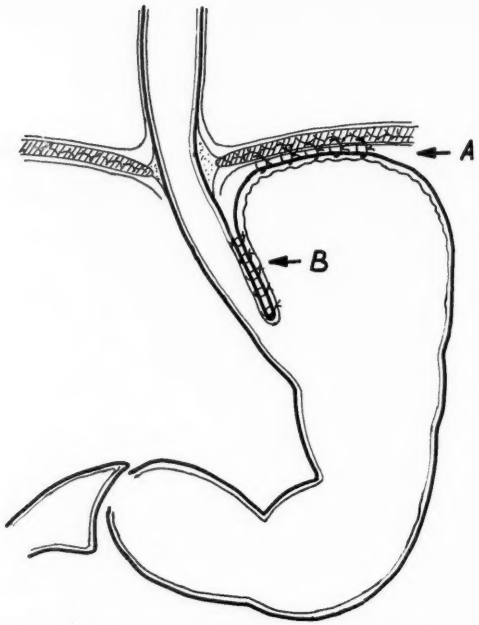

Fig. 4.—*A*, Sutures between diaphragm and fundus of stomach. *B*, Sutures between esophagus and stomach restoring a normal esophagogastric junction.

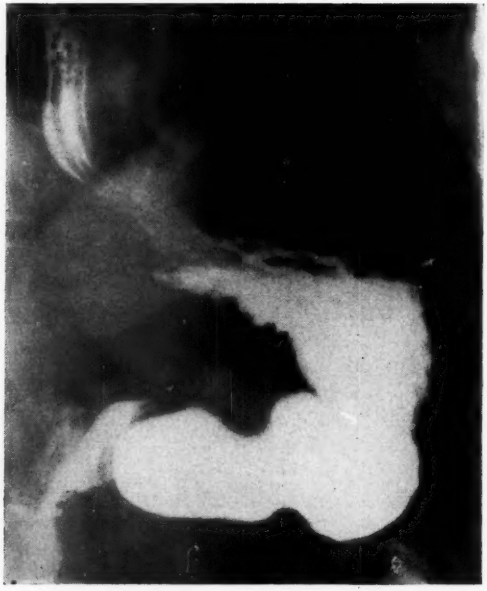

Fig. 5.—Postoperative x-ray corresponding to Fig. 4.

An operation was performed through a thoraco-abdominal incision. The hiatus was normal. The junction of the esophagus with the stomach was found to be a right angle, anteriorly. The fundus was then sutured upward laterally and to the left of the esophagus. It was fastened to the left dome of the diaphragm and farther, with interrupted sutures, downward along the esophagus (Fig. 4).

There were no postoperative complications. Control examination six months after the operation found the patient free of symptoms. He was completely satisfied with the result of the operation. X-ray of the esophagus, stomach, and duodenum now shows a normal relation between the esophagus and stomach (Fig. 5) and there is no regurgitation. Esophagoscopy revealed a slight esophagitis, considerably less than at the postoperative examination, also without regurgitation.

DISCUSSION

I have found no reports in the literature of similar cases in which an operation has been performed. But Barret[2] mentions that Lortat-Jacob has performed several operations on similar cases with good result.

We believe that this condition, an incompetent cardia without hiatus hernia, occurs but rarely. This condition is not always diagnosed. It seems that these patients can be cured by a minor operation.

SUMMARY

A case of cardiac insufficiency without hiatus hernia was treated surgically by a plastic operation with a good result.

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LOBECTOMY FOR PULMONARY TUBERCULOSIS

An Analysis of 301 Cases

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LOBECTOMY for pulmonary tuberculosis was already introduced in 1945 by Overholt and Chamberlain. The results have improved due to the antimicrobial therapy. The aim of this paper is to report a group of 301 cases. One-half of this group has been followed for one to five years. The immediate and late results are given with special reference to the lung function after lobectomies with different space-diminishing procedures.

MATERIAL

In this group, even patients with a very bad pulmonary function have been accepted. Of the 301 patients, 10 are dead and 163 have been followed. Ninety-one patients were excluded as the observation time was less than one year. Twenty-three patients have refused follow-up tests mainly because they did not like to have another bronchospirometry. Fourteen patients have not been traced.

Only patients with lobectomies are included, except in 39 cases of the 301 in which a wedge resection was added to the lobectomy. All patients with segmental resections are reported later.

Nearly one-half of the patients, i.e., 48.5 per cent, had bilateral pulmonary tuberculosis. The extent of the tuberculosis in the contralateral lung is shown

Table I. The Condition of the Contralateral Lung at the Time of Operation

CONDITION OF THE CONTRALATERAL LUNG	NUMBER OF CASES
Normal	155
Old pleurisy	5
Small infiltration	69
Infiltration earlier treated by pneumothorax	19
Infiltration being treated by pneumothorax	6
Cavity "closed" by conservative treatment including chemotherapy	5
Cavity "closed" by pneumothorax	10
Cavity "closed" by thoracoplasty	4
Open cavity	17
Open cavity under pneumothorax	7
Open cavity under thoracoplasty	3
Pneumonectomy	1
Total	301

From Sabbatsberg Hospital; Surgeon in Chief: C. Crafoord, M.D., Professor. St. Göran Hospital; Physician in Chief: A. Westergren, M.D., Professor, and Söderby Hospital; Physician in Chief: T. Bruce, M.D., Docent.

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in Table I. Twenty-seven patients had an open cavity in the contralateral lung. In more than one-half of the material, 54.5 per cent (164 cases), it was necessary to do an extrapleural resection or a decortication.

AGE

Old age is not in itself a contraindication to the removal of a lobe with cavitary tuberculosis. Due to emphysema and fibrosis of the remaining lung, it will often be found necessary to add an osteoplastic thoracoplasty at the same operation. There were 5 patients in this material operated upon at an age above 60 years. In all 5 cases, a lobectomy with simultaneous osteoplastic thoracoplasty was carried out. Four patients withstood the procedure very well. The fifth patient, a 64-year-old man died from circulatory insufficiency two days after the operation.

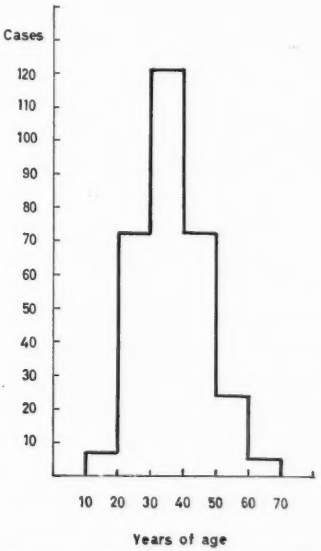

Fig. 1.—The age distribution in 301 cases of lobectomy for pulmonary tuberculosis.

In old patients with some coronary insufficiency, the postoperative course must be especially carefully supervised. Some atelectasis with shunting of blood and a decrease of the arterial oxygen tension must be prevented. If electrocardiography shows some signs of a coronary insufficiency, I believe a tracheostomy with prolonged artificial ventilation may save the patient from death in circulatory insufficiency.

Seven patients were operated on under the age of 20, the youngest being a 15-year-old patient who had a left lower lobectomy with a tailoring thoracoplasty (removal of posterior segments of ribs 2 to 8). I do not like to add a thoracoplasty to young growing patients and have therefore devised an operation which includes the mobilization of the diaphragm around its periphery with fixation at a higher level, usually to the fifth intercostal muscle bundle. The age and sex distribution is shown in Table II and Fig. 1.

TABLE II. AGE AND SEX DISTRIBUTION IN 301 PATIENTS UNDERGOING LOBECTOMY FOR PULMONARY TUBERCULOSIS

AGE	MEN	WOMEN	TOTAL
10-19	3	4	7
20-29	37	35	72
30-39	61	60	121
40-49	46	26	72
50-59	19	5	24
60-69	4	1	5
Totals	170	131	301

INDICATIONS FOR LOBECTOMY

1. Tuberculous Cavitation.—The most common indication for the lobectomy has been cavitary tuberculosis in 85 per cent, or 255 cases. The right upper lobe was the most common localization, i.e., 59 per cent compared to 26 per cent left upper lobectomies for cavitation. This very high incidence of right upper lobectomies will be explained by the fact that on the left side a segmental resection of the apicoposterior and eventually also the anterior segments is very often carried out for cavitary tuberculosis. Although I have always tried to leave the anterior segment of the right upper lobe when it contained no palpable tuberculosis there was actually a high frequency of lobectomies.

In comparatively few cases, a lower lobe cavity was the indication for a resection, i.e., 28 cases, or 11 per cent, on the right side, and 11 cases, or 4 per cent, on the left side.

There was no case of isolated cavitary tuberculosis in the middle lobe. However, in 22 cases, or 8 per cent, the middle lobe was resected for cavitary tuberculosis, in 14 cases, or 5 per cent, in combination with the upper lobe, and in 8 cases, or 3 per cent, in combination with the lower lobe.

2. Bronchial Stenosis.—Bronchial stenosis was the indication for resection in 26 patients, i.e., 9 per cent of the material. This stenosis was localized to the right main bronchus in 2 cases, to the left main bronchus in 3 cases, and in all 5 patients the upper lobe bronchus was also stenosed. The lobar bronchus alone was involved in the right upper lobe in 11 cases, in the right middle lobe in 2 cases, the right middle and lower lobes in 4 cases, left upper lobe in one case, and in the left lower lobe in 3 cases.

3. Bronchiectasis.—Bronchiectasis with positive sputum was the indication for resection in 6 patients, or 2 per cent (2 right upper, 1 left upper, and 3 in the right middle and lower lobes). All these patients had had bronchial disease and showed some narrowing or deformation of the lobar bronchus.

4. Tuberculous Pneumonia.—Tuberculous pneumonia was the indication for resection in 6 cases, or 2 per cent. The right upper lobe was involved in 4 cases, the right lower lobe in one case, and the left upper lobe in one case.

5. Tuberculous Empyema With Bronchial Fistula.—In 7 cases, a tuberculous empyema with bronchial fistula was the indication for resection. Two of these fistulas were caused by an extrapleural plomb of plastic material (Polystan).

6. Secondary Infected Congenital Cyst.—One patient was followed with the diagnosis of congenital cyst from 8 years of age when a Mantoux test was negative. Later he developed a tuberculous infection in the congenital cyst and, at the age of 22, a resection of the right lower and middle lobes was performed.

PREOPERATIVE INVESTIGATION OF LUNG FUNCTION

The most important information of the lung function was obtained by a study of all x-ray films from the beginning of the disease. The maximal movements of each diaphragm are also recorded.

1. The Maximal Breathing Capacity (MBC).—The lowest preoperative value for MBC was 20 L. per minute in a 31-year-old woman who had had bilateral pneumothorax treatment. Before the operation she had had a long period of breathing exercise training and increased the MBC to 32 L. per minute. After resection of the right upper and middle lobes under an old 3-rib thoracoplasty the patient awoke but failed to get strength enough to take over adequate spontaneous ventilation and died. This happened before we introduced the prolonged postoperative artificial ventilation. The lowest preoperative value for a surviving patient was 26 L. per minute in a 50-year-old woman who had a resection of the right upper lobe and a wedge resection of the lower lobe under an old 5-rib thoracoplasty. This patient is still doing full time office work five years after operation. The MBC was below 69 L. per minute in 50 per cent of the women and below 49 L. in 14 women.

In 50 per cent of the men, the MBC was below 100 L. per minute and 9 cases had an MBC of less than 49 L. per minute. The lowest preoperative MBC in a man was 28 L. per minute. This patient was 33 years old and had had a left 7-rib thoracoplasty and then a right upper lobectomy under a 3-rib thoracoplasty. He survived the operation with spontaneous ventilation and, two years later, is working full time as an engineer and his MBC is still 28 L. per minute.

2. The Vital Capacity.—The lowest preoperative value for vital capacity was 0.84 L. in a 42-year-old woman with a left-sided 8-rib thoracoplasty fifteen years old. Eighty-nine per cent of the total oxygen uptake came on the right side where the upper and middle lobes and a wedge of the lower lobe were resected and an osteoplastic thoracoplasty performed at the same time. The patient withstood the operation well with the aid of prolonged artificial ventilation but died fourteen months later from cor pulmonale.

3. Bronchospirometry.—One of the most valuable preoperative investigations was bronchospirometry. Due to the instrument designed by Carlens, it has been possible to obtain a number of postoperative determinations and these findings are reported under "Results."

4. The Residual Capacity.—The residual capacity was investigated in 153 cases. It was found to be below 35 per cent of the total capacity in 130 cases, between 35 and 40 per cent in 16 cases, between 40 and 45 per cent in 5 cases, and more than 45 per cent in 2 cases.

5. The Pulmonary Artery Pressure.—The pressure in the pulmonary artery was only recorded in 15 cases and, in most of these patients, during operation.

The highest value was 35 mm. Hg mean pressure in a 50-year-old woman. She is, five years after operation, doing office work full time. On the other hand, the mean pressure in the pulmonary artery during operation in a 42-year-old woman was only 23 mm. Hg and yet she died from cor pulmonale fourteen months afterward. From this limited experience, it seems difficult to make any long time prognosis based on the pulmonary artery pressure. The lowest value was 7 mm. Hg mean pressure in a patient with a pulmonary valvular stenosis, where the right ventricular pressure was 171/4 mm. Hg. Pulmonary resection and a valvulotomy through the pulmonary artery was successfully performed and the right ventricular pressure returned to 24/3 mm. Hg and the pulmonary artery pressure rose to 17/6 mm. Hg (mean pressure 12 mm. Hg).

METHOD OF TREATMENT

In only 18 cases (6 per cent) was the lobectomy performed without a space-diminishing procedure. In only 2 patients in which a thoracoplasty was omitted at the time of resection was it necessary to add it after 11 days and 5 months later, respectively, to obliterate a remaining space.

When the decision was made to add a space-diminishing procedure to the resection, the quantity of the resected lung as well as the quality of the remaining lung parenchyma had to be considered. I have usually added a space-diminishing procedure under the following circumstances: (1) when more than one lobe is resected, (2) palpable tuberculosis in the remaining lung, (3) contralateral disease, (4) after resection of a tuberculous empyema, (5) after an accidental opening of a tuberculous cavity or an empyema, and (6) when the remaining lung is emphysematous and fibrotic and does not fill the space.

A one-stage procedure is always to be preferred. In the beginning, a preliminary 3-rib (33 cases, i.e., 11 per cent), or a 5-rib thoracoplasty (14 cases, i.e., 5 per cent) was performed and after a few months up to a year later the resection was performed with additional rib resection if considered necessary.

Later a one-stage operation has always been used. First, an extrapleural Polystan plombage was used in 10 cases, then a tailoring thoracoplasty with resection of posterior parts of ribs 2 to 5, 6, or 7 was performed.

To avoid the immediate danger of paradoxical movements of the chest wall with carbon dioxide retention and the late hazards of infection in a foreign body, I designed an osteoplastic thoracoplasty with fixation of the posterior parts of the ribs by nylon sutures through drill holes. The first rib is usually left behind. The second rib is incised close to the sternum and placed as close as possible to the mediastinum, its posterior end being fixed to the costovertebral ligaments by a thread behind the posterior tip of the intact sixth rib. Then a row of five to ten isolated sutures will approximate the first intercostal muscle bundle (attached to the second rib) to the mediastinal pleura. The addition of an osteoplastic thoracoplasty to a lobectomy has been performed in 149 cases in this material.

Although the cosmetic result has been very good, with the main deformity in the axilla, and the arm movements practically unimpaired, I like to avoid thoracoplasties in young growing individuals and when possible even in the

grown-up patients. I have therefore lately mobilized the diaphragm around its periphery and resutured it to the fifth intercostal muscle. Three such cases are included in this material.

The lobectomy was performed under an old thoracoplasty of 7 ribs in 19 cases, of 5 ribs in 26 cases, and of 10 ribs in one case. This thoracoplasty had been performed one to fourteen years before the resection.

In 3 cases, a preliminary plomb had caused perforation into a tuberculous cavity with empyema. The plomb was removed in one piece with the chest wall and the lobe. The chest wall was resected together with an empyema and a lobe after an extrapleural pneumothorax in one case.

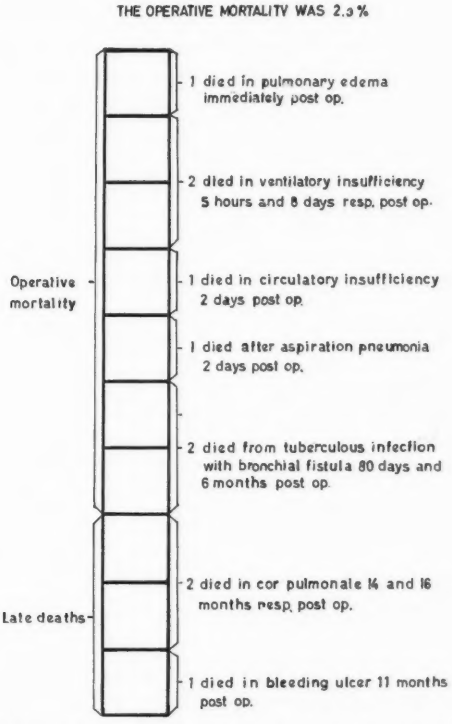
THE OPERATIVE MORTALITY WAS 2.3 %
1 died in pulmonary edema immediately post op.
2 died in ventilatory insufficiency 5 hours and 8 days resp. post op.
Operative mortality
1 died in circulatory insufficiency 2 days post op.
1 died after aspiration pneumonia 2 days post op.
2 died from tuberculous infection with bronchial fistula 80 days and 6 months post op.
2 died in cor pulmonale 14 and 16 months resp. post op.
Late deaths
1 died in bleeding ulcer 11 months post op.

Fig. 2.—The operative mortality was 2.3 per cent, or 7 cases. There were 3 late deaths.

RESULTS

Dead.—Altogether, 10 patients are dead.

The operative mortality was 2.3 per cent (7 cases).

One 40-year-old woman had a right upper lobectomy under an old 5-rib thoracoplasty. When the wound was closed and immediately after injection of Prostigmin she suddenly developed pulmonary edema. Clear fluid poured out from both lungs in such an amount that it could not be effectively sucked away through the openings of a Carlen's double lumen catheter. As I had

never had such an experience before, I did not remove the Carlen's tube and introduce a bronchoscope for a more effective aspiration, which might have saved the patient. As a consequence, I now do not use the Carlen's double lumen catheter for anesthesia except in a few very wet cases, but have adopted the Overholt prone position for most patients.

Two patients died from ventilatory insufficiency five hours and eight days after the operations, respectively. Both patients had had bilateral pneumothorax earlier and were operated upon before we introduced the prolonged postoperative artificial ventilation.

One 64-year-old man died two days after operation from circulatory insufficiency.

One 34-year-old woman had had a left pneumonectomy three months earlier. At a second operation, a right upper lobectomy was performed as well as an osteoplastic thoracoplasty. She was in good condition for two days when she vomited, developed aspiration pneumonia, and died. She, too, was operated on before the introduction of prolonged artificial ventilation. With this treatment, an aspiration is prevented due to the cuffed tracheal cannula.

Two patients, both having tuberculous empyema before operation, died from the tuberculous infection opening the bronchus, one within eighty days, the other six months after operation. There were three late deaths. Two patients died fourteen and sixteen months, respectively, after operation from cor pulmonale. The third patient died eleven months after operation from a bleeding ulcer.

Other Complications.—

Spillover was encountered in 2 cases. In one of these, there was a contralateral pneumothorax and a tracheostomy had to be performed. Patients with a pneumothorax on the contralateral side or with fixation of the diaphragm due to an old pneumothorax usually have difficulty in producing an effective cough and therefore a tracheostomy has to be added for aspiration of secretions and for diminishing the dead space as the respiratory work is greatly increased in these cases.

Ventilatory insufficiency was the reason for a tracheostomy in 3 cases, and the addition of postoperative prolonged artificial ventilation in 5 cases.

A residual space necessitated the insertion of a drainage tube in 4 patients and an additional thoracoplasty eleven days later in one case, and five months after operation in another case.

Hemorrhage: A severe postoperative hemothorax was encountered in 4 cases. The hematoma was not evacuated in 2 patients resulting in infection which necessitated an extrapleural pneumonectomy in one case and resection of the middle lobe and the chest wall in another case. The hematoma was evacuated after seventeen days in one case, but first a staphylococcus then a fungus infection necessitated a 3-month period of drainage with local chemotherapy.

In the fourth case, the hematoma was evacuated within twenty-four hours after operation and this patient then had an uncomplicated postoperative

course. In 2 other cases of segmental resection where a hemothorax complicated the postoperative course, re-operation was therefore performed after twelve and thirty-six hours, respectively, and then the recovery was uneventful. I will therefore continue to re-operate on patients with a postoperative hemothorax as early as possible to avoid the development of an infected hematoma and a bronchial fistula.

Infection: In one case, an extrapleural Polystan plomb had been introduced after a right upper lobectomy. It became infected and caused a bronchial fistula necessitating extirpation of the plomb and the chest wall corresponding to the upper 8 ribs in two stages before healing occurred.

A tuberculous cavity was opened on four occasions and resulted in a tuberculous empyema with prolonged drainage treatment needed in 2 cases.

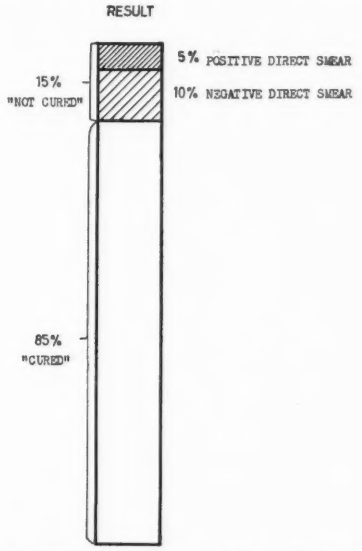

Fig. 3.—Eighty-five per cent were considered "cured." Only 5 per cent were positive on direct smear.

Suture granulomas in the bronchus were found in 14.5 per cent of the cases when stainless steel or silk sutures were used, and had to be removed through the bronchoscope before I switched over to 30-day chromic catgut (Ethicon).

"Cured Patients".—

As the aim of the surgical treatment of pulmonary tuberculosis is to make the patient free from tuberculous bacilli in the sputum the following criteria of a "cure" were chosen: (1) negative guinea pig test on gastric washing and sputum, negative culture of sputum, and negative direct smear on three consecutive days, and (2) no active disease found on x-ray examination. All these criteria were fulfilled in 125 of the "cured" patients.

In the remaining 14 cases it was not possible to obtain sputum and therefore only the gastric washing test was performed and found negative. Altogether a "cure" was obtained in 139 cases of 163 followed up, i.e., 85 per

cent. A negative direct smear was found in 17 of the 24 patients considered "not cured," making a total of 156 cases, i.e., 96 per cent with a negative direct smear.

Two of the "cured" patients had had some reactivation shortly after the operation but reacted promptly to antimicrobial therapy.

Working capacity: Of the "cured" 139 patients, 110, or 79 per cent, were working full time one year after operation. Twenty-six different professions were represented. Housework and office work were most frequently found, although some patients performed more heavy work. Twelve patients performed a one-half day's work and 17 did not work at all. Of these nonworking patients, 2 had been in sanatoriums for eight and thirteen years, respectively, and had never performed any work. One patient was not allowed to

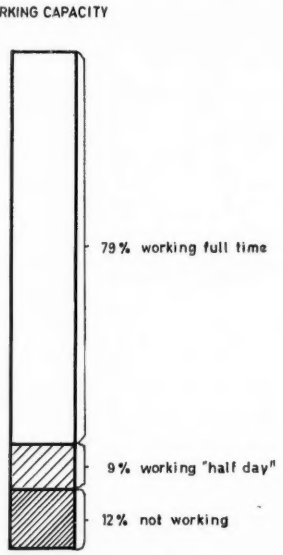

Fig. 4.—The working capacity.

take up work by her mother. Five patients had done heavy work before surgery and could not resume the same work.

The arm movements: The postoperative arm movements were recorded and compared in 2 groups of patients having had thoracoplasties.

1. In 50 cases with an osteoplastic thoracoplasty, 47 cases, or 94 per cent, had perfect arm movements. In 3 cases, there was a deficient ability to bring the arm on the operated side straight up in the air (i.e., 180 degrees). Two patients could bring the arm to 175 degrees and one patient having had a tuberculous empyema in the apicolysis space could only bring the arm to 160 degrees.

2. In 93 patients having had conventional thoracoplasties with rib resections, the arm movements were normal in 70 cases, i.e., 75 per cent. Twenty-three cases, or 25 per cent, had a deficient ability to bring the arm on the

operated side straight up in the air (180 degrees). One patient could bring this arm to 175 degrees, 8 patients to 170 degrees, 6 patients to 165 degrees, one patient to 160 degrees, 3 patients to 150 degrees, 3 patients to 140 degrees, one patient to 120 degrees, and one patient to 90 degrees.

Although this group includes 3 patients with chest wall extirpation in one block with infected plombes who could only bring up the arm on the operated side to 160, 150, and 90 degrees, respectively, there were many more patients with impaired arm movements than in the group with osteoplastic thoracoplasty. This difference is statistically significant ($0.01>P>0.001$).

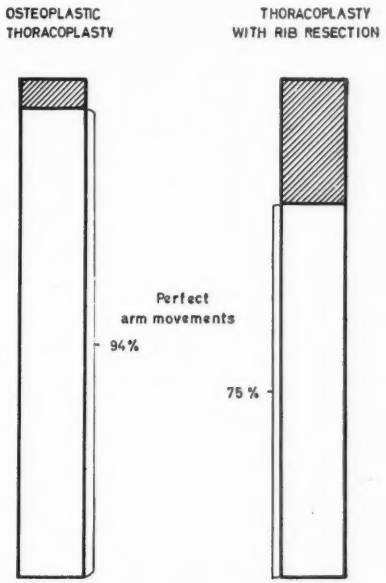

Fig. 5.—There was a considerably better cosmetic and functional result regarding the arm movements in the patients having an additional osteoplastic thoracoplasty as compared to patients having thoracoplasty with rib resection. This difference is significant.

One explanation of the better functional result when an osteoplastic thoracoplasty was added to the resection is that this was a one-stage procedure, while, in the other group, thoracoplasty with rib resection, at often two and sometime several stages, was performed. Naturally a division of the periscapular muscles several times will give a bad functional result.

Pain: During the first months after an osteoplastic thoracoplasty, several patients experienced some pain on the operated side, sometimes radiating out into the arm. There was also a loss of sensitivity because the upper 5 intercostal nerves are divided. Leaving the first rib has, in one patient, caused radiating pain in the arm, necessitating the removal of the rib. After one year, 80 per cent of the patients with osteoplastic thoracoplasty were completely free from pain. The remaining 10 patients complained about the following discomfort.

Four patients had some pain radiating out into the arm. (The pain was not intensive enough to warrant the removal of the first rib.) Two patients complained of some pain under the scapula and in one of them a bursa was removed under the scapula. In 2 other cases, a bursa was found but disappeared on repeated aspirations with injection of dihydrocortisone.

One patient had pain in the side of the thoracoplasty when there was a change in the weather. One patient noticed some discomfort in the third costochondral junction and 2 patients had some pain when the scapula during maximal movements jumped over the sixth and seventh ribs, respectively.

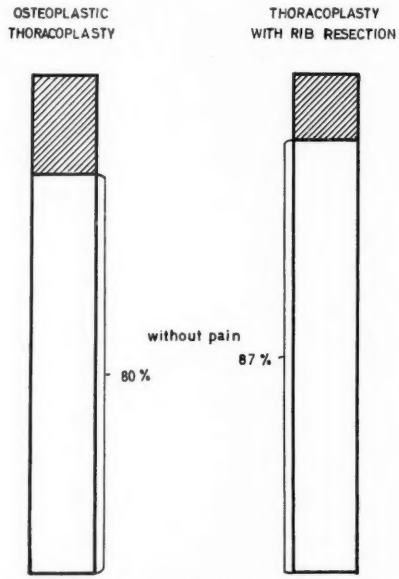

Fig. 6.—The incidence of pain was slightly higher in the patients having an osteoplastic thoracoplasty. This difference is not significant.

In the second group of patients with rib-resection thoracoplasties, 81 cases, or 87 per cent, were free from pain. Eleven patients complained of some pain: 2, in the arm; 4, under the scapula; 3, when the scapula jumped over the intact seventh rib; and, in one case when scapula jumped over the intact sixth rib. One patient complained of pain over the lower costal margin. Furthermore, the scapula jumped over or could fasten under the seventh rib or some rib regeneration in 6 cases without causing the patient any pain.

Somewhat more pain is therefore found postoperatively in the group with osteoplastic thoracoplasty although the difference is not great and is not statistically significant ($P = 0.20$). The cosmetic and functional result with the osteoplastic thoracoplasty, however, is far superior. The group with rib resection has been followed longer than the group having had an osteoplastic thoracoplasty. As the pain usually disappears with time, especially after the patient is fully occupied with his work, the five-year follow-up may be more favorable.

Cough: Seventy per cent of the patients did not have any cough. The remaining 30 per cent experienced some irritating cough or had some expectoration in the morning. Patients with an irritating cough were bronchoscoped and, in 17 cases, or 35 per cent, of these patients, sutures were removed from the bronchial tree. Several patients had coughed up sutures. But silk or stainless steel sutures were removed from the bronchial stump as long as four years after operation. Some of these patients were positive to guinea pig

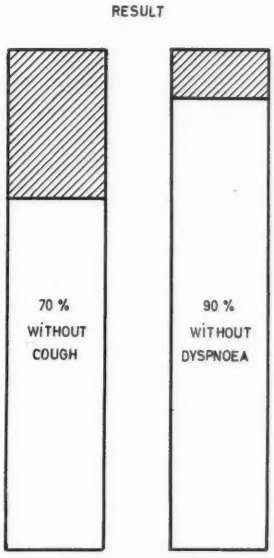

Fig. 7.—As many as 30 per cent of the patients had cough at the follow-up. Only 10 per cent complained of shortness of breath.

test, but turned negative after removal of sutures and suture granulomas containing tuberculous tissue. I have therefore adopted the use of 30-day chromic catgut on Atraumatic needles (Ethicon) for bronchial closure and bronchotracheal anastomosis.

Dyspnea: Ninety per cent of the patients did not feel short of breath. The remaining 10 per cent complained of dyspnea. In the patients with a subjective feeling of shortness of breath, the maximal breathing capacity varied from 76 to 16 L. per minute for the male and from 64 to 22 L. per minute for the female patients.

Not "Cured" Patients.—

Late reactivation: Six patients with bilateral disease at the time of operation had reactivation; in both lungs, one to two years after resection in 4 cases, and cavitation in the remaining lung after operation in 2 cases. Five patients were readmitted for antimicrobial therapy, and one for a new resection.

Contralateral disease: In 8 cases, the disease in the contralateral lung was considered the origin of the tuberculous bacilli. In 5 of these cases, there was

a cavity in the contralateral upper lobe at the time of operation. Two of these 5 patients have already had segmental resections for removal of the remaining cavitary disease and may come over in the group of "cured" patients at a later date. Two patients are going to be operated upon but the third has been postponed as he has no functional reserve. This is a 36-year-old man with only 28 L. per minute maximal breathing capacity. He has a residual cavity in the left upper lobe under a 7-rib thoracoplasty. After a right upper lobectomy and a 5-rib thoracoplasty, he had still 23 per cent of the total oxygen uptake and 32 per cent of the ventilation on the left lung. The decision to postpone an eventual left upper lobectomy was made before the introduction of the prolonged postoperative artificial ventilation. He had a marked dyspnea walking on level ground but did full time work as a construction engineer.

Two patients with significant apical infiltration have now been working full time for three and four years, respectively, and are negative on direct smear and on guinea pig test of the gastric washing, but the guinea pig test on sputum is positive.

Patients positive to guinea pig test without x-ray evidence of active disease: Eight patients had a positive guinea pig test but were negative on examination of the direct smear and the chest; x-ray was without evidence of active disease. Only 3 of these patients had had bilateral disease. Five patients in this group were working full time, one could not work due to retinitis pigmentosa, one did one-half day's work as a clerk (a man with 38 L. per minute maximal breathing capacity). The last patient, a 52-year-old man, had not yet started his heavy work as a blacksmith, one year after surgery.

Two patients had had postoperative tuberculous empyema with tuberculous osteitis and fistulation. One had a revision thoracoplasty, the other seems to heal with local application of antimicrobial therapy. Both patients were negative on direct smear but had positive guinea pig tests. After removal of a suture granuloma in the bronchus, one of the 2 patients is now negative to guinea pig test of sputum as well as to gastric lavage.

THE FUNCTIONAL RESULT

In order to obtain some information about the functional result after lobectomies with and without different types of thoracoplasties, the oxygen uptake and ventilation on the operated side have been recorded by bronchospirometry one year after operation in a group of patients without present or earlier contralateral pleural or pulmonary disease. The results are given in Table III. It is due to the work by Carlens, first, by the construction of the flexible double lumen catheter and, then, by his actual performance of the bronchospirometric investigation that it has been possible to obtain the permission of a large number of patients to undergo this investigation a year after the operation. From Table III, it can be seen that after removal of the right upper lobe, around 38 per cent of the oxygen uptake remains, regardless of the type and extent of the thoracoplasty. The additional resection of the middle lobe resulted in a loss of a further 12 per cent of the total oxygen uptake. Roughly, the same function, i.e., 26 per cent, remained after removal of upper

TABLE III. THE POSTOPERATIVE FUNCTIONAL RESULT IN UNILATERAL CASES OF PULMONARY TUBERCULOSIS

OPERATION		NUMBER OF CASES	FUNCTION OF THE OPERATED SIDE IN PER CENT OF THE TOTAL					
			OXYGEN UPTAKE		VENTILATION		VITAL CAPACITY	
			MEAN VALUE	RANGE	MEAN VALUE	RANGE	MEAN VALUE	RANGE
Resection right upper lobe	with osteoplastic thoracoplasty	15	38	27-49	50	37-69	38	34-48
	resection costae 1-5 in 2 stages	7	41	32-49	42	36-49	39	28-42
	+costae 1-7 in 2-3 stages	4	38	29-59	47	36-59	46	33-63
	+costae 1-8 in 3-4 stages	2	38	30-46	39	35-42	32	27-36
Resection right upper and middle lobes	+costae 1-7	3	26	23-28	39	31-44	32	22-40
Resection right middle lobe		1	42		46		47	
Resection right lower lobe	+apical plombage	1	21		39		22	
	+costae 7-11	1	36		43		39	
Resection right lower and middle lobes	without thoracoplasty	1	26		49		36	
	+costae 1-6 or 1-8	2	26	25-26	34	38-49	33	29-35
	+costae 4-10 or 7-10	2	23	23-23	33	32-33	25	24-26
	+apical extrapleural plombage	1	16		29		24	
	+osteoplastic thoracoplasty	2	25	24-25	36	34-38	32	27-36
	+diaphragm plasty	1	27		32		31	
Resection left upper lobe	with osteoplastic roof thoracoplasty	9	32	23-39	32	23-44	32	25-44
	with resection costae 1-5	4	32	24-43	38	22-53	33	27-40
	with resection costae 1-7	4	24	17-41	18	14-22	21	18-23
	with resection costae 1-8	1	6.3		9.5		24.2	
	without thoracoplasty	1	16		11		22	
Resection left lower lobe	with osteoplastic roof thoracoplasty	2	22	21-23	21	18-23	24	23-24

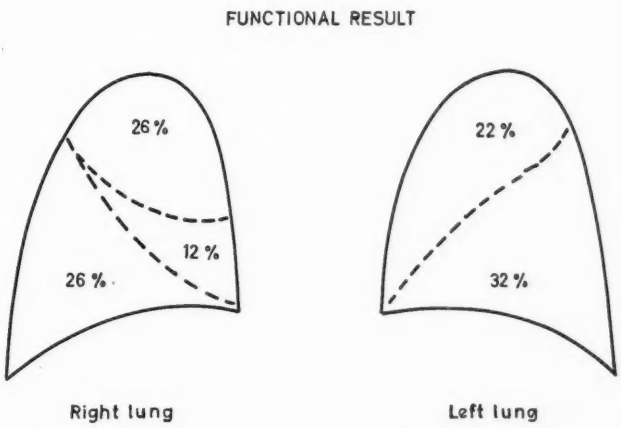

Fig. 8.—The functional result found by bronchospirometry at the follow-up. The percentage given indicates the percentage of oxygen uptake of the remaining lobe after lobectomy in patients with a normal contralateral lung.

and middle lobe as after the lower and middle lobe. On the left side, 32 per cent of the oxygen uptake remained after an upper lobectomy with an osteoplastic thoracoplasty or the resection of the upper five ribs. A significant decrease of function was found when more ribs were resected. Removal of the left lower lobe with an osteoplastic roof thoracoplasty left 22 per cent of the total oxygen uptake on the left side.

It must be noted in one case with phrenic crush and then a total collapse of the right lung for nine years, under a tuberculous empyema in a pneumothorax space, that after decortication and resection of the upper lobe and 5 ribs, 33 per cent of the oxygen uptake and 46 per cent of the ventilation remained on the right side in spite of the fact that it had been collapsed for such a long time.

A comparison of the oxygen uptake and ventilation of each side before and after a resection is only considered to be of secondary interest as (1) the resected lobe is more or less destroyed and without function, and (2) very often a decortication is added which will make the function better after the resection than it was before.

In 34 cases, the function on the operated side was compared before and after lobectomy and the mean difference was for:

the oxygen uptake	-2.8%	range + 22% to -23%
the ventilation	-0.1%	range + 23% to -36%
the vital capacity	-2.6%	range + 16% to -23%

In the case with the greatest loss of function, i.e., 23 per cent of the oxygen uptake, the right upper lobe was resected in one block together with an infected plomb and the chest wall corresponding to the upper 7 ribs. The greatest improvement of function, i.e., 22 per cent of the oxygen uptake was recorded after a left upper lobectomy with decortication. A gain in oxygen uptake of 11 per cent of the total on the left side was obtained after the removal of a left upper lobe and a thrombus in the pulmonary artery obstructing about 90 per cent of its lumen.

When the maximal breathing capacity was compared before and after resection a significant decrease was found, i.e., 20 L. per minute in men (range +19 to –56) and 13 L. per minute in women (range +22 to –47).

CONTRALATERAL DISEASE

There were 8 patients with a positive guinea pig test in the 94 who had a normal contralateral lung at the time of operation. Of these, 3 had disease on the operated side and in 4 patients, working full time, the source of the positive guinea pig test could not be detected. Only in one of these 94 patients was an infiltration found in the contralateral lung, which was normal at the time of operation.

In a group of 37 patients having small infiltrations in the contralateral lung at the time of operation, 9, or 25 per cent, had a positive guinea pig test one year after operation.

Nine patients had an open cavity on the contralateral side at the time of operation. In 4 patients the cavity remained open, in 4 bilateral resection had been performed, and in one the cavity was closed.

In the whole group of 68 patients with earlier contralateral disease as many as 50, or 74 per cent, were negative to guinea pig test one year after the resection. Of the remaining 18, 4 now have already had a bilateral resection. It must therefore be concluded that the contralateral lung has withstood the resection very well, see Table IV.

TABLE IV. THE CONDITION OF THE CONTRALATERAL LUNG AT THE TIME OF OPERATION CORRELATED TO THE RESULT AT THE FOLLOW-UP

CONDITION OF THE CONTRALATERAL LUNG	"CURE"	RECURRENCE	TOTAL
Normal	86	8	94
Old pleuritis	1		1
Small infiltration	28	9	37
Infiltration treated by pneumothorax	6		6
Cavity closed by conservative treatment	3	1	4
Cavity closed by pneumothorax	12		12
Open cavity	1	8	9
Totals	137	26	163

SUMMARY

An analysis is made of 301 cases of lobectomies for tuberculosis. Although patients with ventilatory insufficiency were accepted for surgery, the operative mortality was only 2.3 per cent. Of the 163 patients followed up from one to 5 years, it has been gratifying to find 98 per cent with a negative direct smear and 85 per cent with a negative culture and guinea pig test to sputum and gastric washing. Seventy-nine per cent were working full time. The incidence of impaired arm movements, pain, cough, and dyspnea are recorded. The osteoplastic thoracoplasty gave a much better cosmetic result and better arm movements as compared to a thoracoplasty with rib resection. There was, however, a higher incidence of postoperative pain, i.e., 20 per cent instead of 13 per cent in the group who had rib resection. The late functional result has been very good after resection with a space-diminishing procedure. There was usually no significant decrease of the oxygen uptake or ventilation on the operated side after a resection although there was a significant decrease of the maximal breathing capacity. The contralateral side has withstood the resection very well.

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MYASTHENIA GRAVIS SECONDARY TO THYMIC NEOPLASM

Report of a Case in Which Symptoms Developed Six Weeks After Total Thymectomy

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THYMIC tumor in association with myasthenia gravis was first noted by Weigert,[1] in 1901. Subsequent reports[2-6] at first suggested that myasthenia gravis occurred with nearly all thymic tumors; other observers,[7-9] however, have found that the disease may be absent and never develops in about 25 per cent of thymic neoplasms. Myasthenia seems less likely to occur with malignant thymic tumors,[8] but the author has had one case with this association and others have been reported.[4, 10, 11] Conversely, it is curious that of all cases of myasthenia gravis, thymic tumor can be demonstrated in about 15 per cent,[8] although some thymic abnormality (hyperplasia) is found in nearly one-half of them.

Thymectomy in the treatment of myasthenia gravis has met with variable success,[8, 12, 13] but it is generally agreed that symptoms are definitely improved by this procedure in many instances, perhaps in more than one-half of the cases.

Careful search of the literature has failed to reveal any description of myasthenia gravis developing after complete removal of thymic neoplasm. Two cases were reported of incompletely removed malignant thymoma in which unmistakable myasthenia complicated the postoperative course. In the case of Fisher and Child,[14] respiratory difficulty developed during operation and the patient died four days later from respiratory complications of the disease. Fershtand and Shaw's case[15] was similar with less certain onset during operation, but postoperative weakness and respiratory embarrassment responded to Prostigmin. This patient improved, later had a temporary remission, and died in one year with recurrent myasthenia gravis and widespread tumor growth. In both of these cases, myasthenia developed coincidentally with or immediately following surgical manipulation and persisted in the presence of remaining thymic tumor tissue. Lack of recognized prior neuromuscular abnormality does not militate against a possible thymic factor in myasthenia; indeed, the course of events in these cases is strong evidence to support the supposed relationship.

The following case represents what is believed to be a unique instance of myasthenia gravis developing in the absence of thymic tissue and at a time well beyond the patient's convalescence from thymectomy.

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CASE REPORT

W. C., a 43-year-old engineer, presented himself on Nov. 18, 1954, with chest roentgenograms demonstrating an abnormal opacity suggestive of tumor. His only symptoms had consisted of a nonpainful tearing sensation with subsequent dull ache in the left shoulder region. He denied dyspnea, cough, hemoptysis, fever, weight loss, weakness, malaise, and night sweats. He had been working actively and playing golf without fatigue up to the time of admission.

Physical Examination.—The examination revealed a robust, healthy appearing, well-nourished man in no distress. The temperature was 98.4° F.; pulse was 76; respiration, 18; and blood pressure, 108/74 mm. Hg. Detailed examination revealed no abnormalities except for a small, easily reducible, right inguinal hernia. There was no ptosis of eyelids or muscular weakness. The chest was normal in contour, with excellent respiratory excursion, no areas of dullness to percussion, and normal breath sounds throughout.

Bronchoscopy was entirely normal.

X-rays.—Plain film of the chest, dated Feb. 2, 1952, showed normal cardiac and mediastinal silhouette with clear lung fields. Chest films, dated March 6, 1954 (including lateral and oblique views and tomograms), demonstrated a well-circumscribed, 2 by 5 cm., density in the region of the left upper lobe bronchus.

Operation.—On Nov. 24, 1954, a left posterolateral thoracotomy was performed under ether-oxygen anesthesia. A plum-sized, soft, encapsulated tumor was found in the anterior mediastinum completely extrapleural and lying on the superior vena cava. There was no evidence of invasion or regional node extension. Satisfactory total excision was accomplished and a frozen section diagnosis of "thymoma" was obtained. Because of the potentially malignant character of this tumor, it was elected to carry out a block dissection of the upper mediastinum cleaning off all tissue between and around the vena cava, aortic arch, innominate, carotid and subclavian vessels, sparing the vagus and phrenic nerves.

Pathology Report.—"A 5 × 5 × 2.5 cm. lobulated discord mass with an irregular surface weighs 45 grams. The cut surface is bulging with lobules up to 2 cm. in diameter. Separately submitted is a mass of mediastinal fat. Histologic examination reveals the main tumor to be made up of small and large groups of round cells resembling lymphocytes, areas of clusters of whorls. Hassall's corpuscles are not seen. The entire tumor is enclosed in a fibrous capsule with attached fat. The mediastinal dissection is found to have abundant fatty tissue in which is embedded microscopic foci of thymic tissue and infrequent tiny lymph nodes. A diagnosis of thymoma is submitted; possible malignancy is considered because of the cellularity of the tumor, but in general it is considered benign."

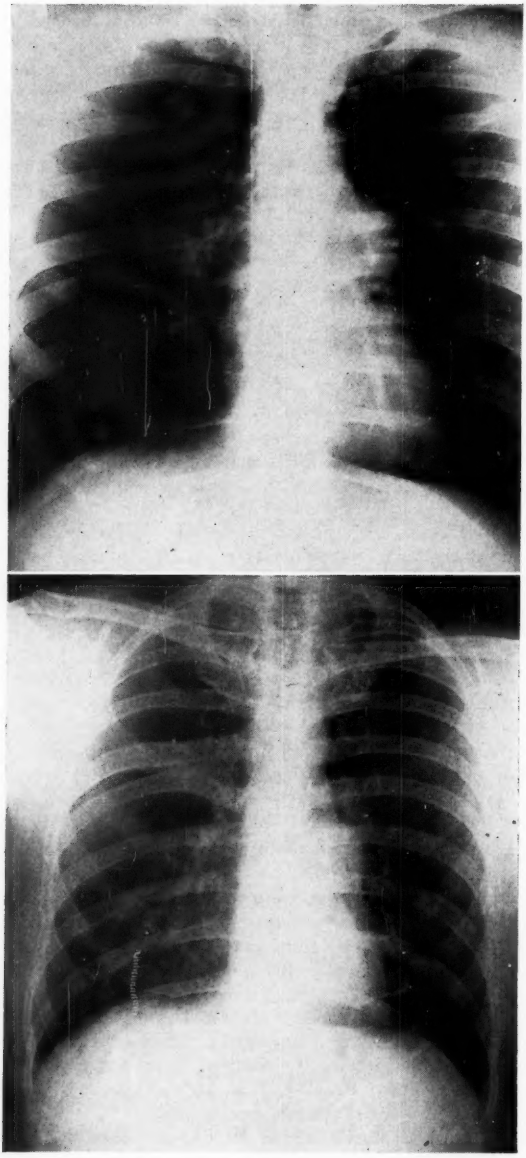
The Postoperative Course.—This was completely uneventful. The patient walked without difficulty from the first day and was discharged on the eighth day. He was closely watched for speech slurring, ptosis, muscular weakness, respiratory difficulty, and other indications of myasthenia gravis, but no such signs appeared during his hospitalization.

The patient was seen during an office visit on Dec. 22, 1954; he had walked eight blocks just before examination and showed no evidence of muscular weakness. He felt certain that he had regained strength progressively since operation and that in retrospect there had been no earlier symptoms. On Jan. 1, 1955, he could eat only with difficulty. His symptoms responded dramatically to Prostigmin, thus establishing the diagnosis of myasthenia gravis on January twenty. He required 60 mg. of neostigmine daily to control symptoms for three months. By May, 1955, he had begun gradually to decrease his requirements and by early 1956 was taking no medication.

He was last examined on March 3, 1956, fifteen and one-half months postoperatively. He had walked eight blocks carrying a suitcase and was not fatigued. He showed no evidence of muscular weakness and reported feeling completely normal. He is working full time without difficulty and plays golf.

An x-ray of the chest on March 2, 1956, showed normal mediastinal silhouette and no evidence of tumor recurrence.

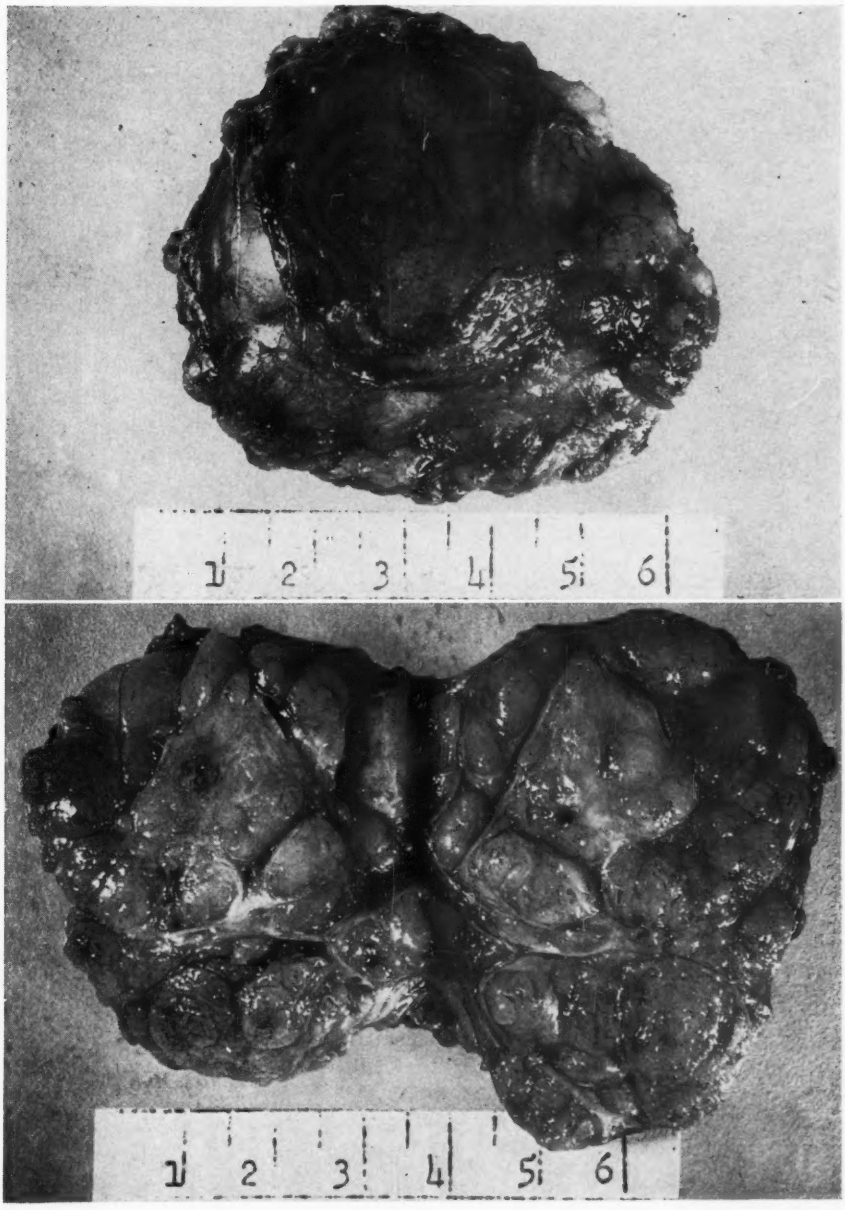
A.



B.

Fig. 1.—*A*, A chest roentgenogram taken preoperatively. *B*, A chest roentgenogram taken three months postoperative.

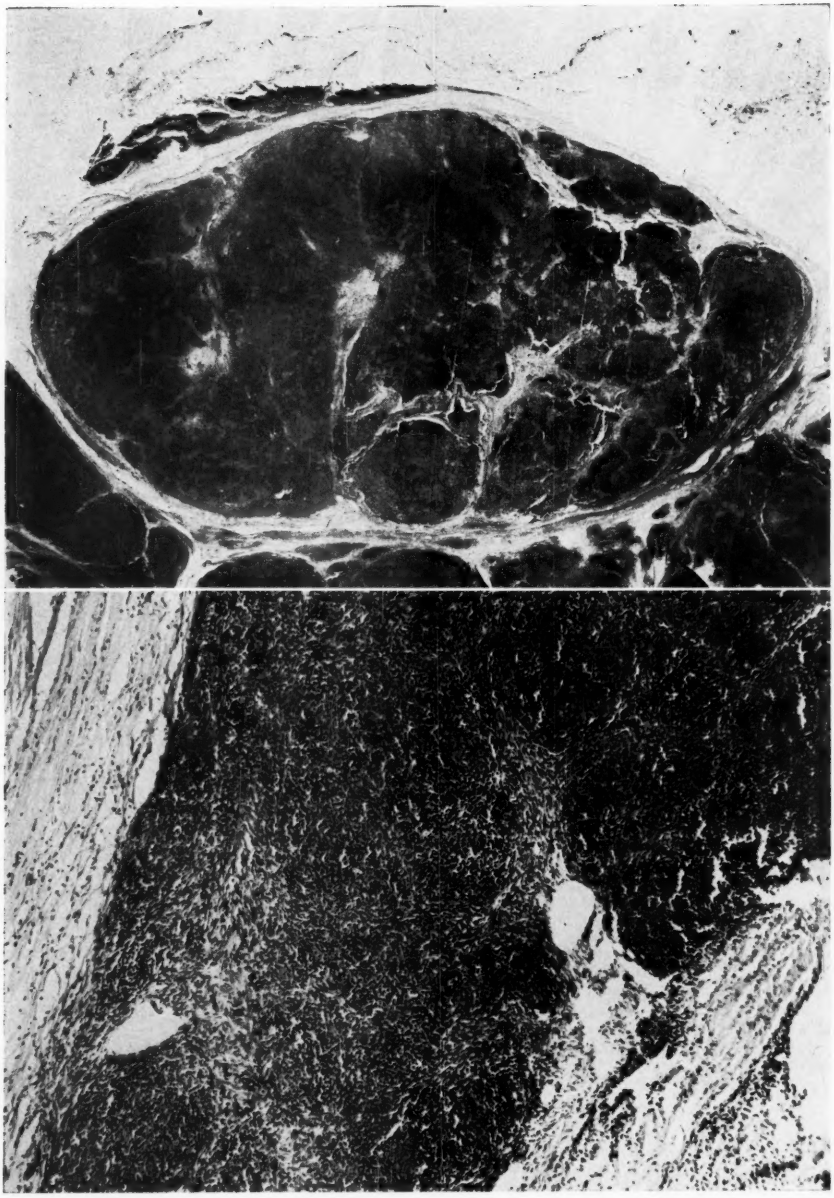
A.



B.

Fig. 2.—*A*, Gross appearance of tumor. *B*, Gross tumor transected.

A.



B.

Fig. 3.—*A*, Photomicrograph of tumor. Note encapsulation and trabeculae. (×25; reduced ⅕.)
B, Photomicrograph of tumor. (×100; reduced ⅕.)

DISCUSSION

There seems to be no satisfactory explanation for the unusual course of events in this case. Secondary tumor growth or hyperplasia of remaining thymic tissue would have to be postulated by adherents of the thymic origin theory of myasthenia gravis. Against this thesis, however, is the complete anterior and upper mediastinal dissection which accompanied the original thymectomy and probably included most of the tissue in which aberrant thymus might occur (though accessory gland tissue has been described both in and below the thyroid gland, laterally in the neck, and behind the sternomastoid muscle). The clinical course of steady spontaneous improvement with minimal dependence upon Prostigmin is curious, but reflected against experiences with thymectomy for myasthenia gravis this is not unusual. Perhaps there is a delayed mechanism between whatever thymic stimulus may occur and the clinical manifestation of the disease. If so, this case may represent an instance of fortuitous therapy which failed to interrupt the already initiated sequence of events but did not abort the clinical course of the disease.

SUMMARY

A case of thymic neoplasm is presented in which distinct myasthenia gravis developed six weeks after total thymectomy and radical mediastinal block dissection. This is a unique occurrence. Related reports in the literature and the problem in general are reviewed.

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SUBPHRENIC ABSCESS

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SUBPHRENIC abscess is not as uncommon as some people believe. The development of this complication should always be borne in mind in all cases in which the diagnosis of an upper abdominal illness is uncertain or in any patient having a stormy convalescence following an upper abdominal operation, such as the closure of a perforated peptic ulcer. Earlier diagnosis and treatment would do much to reduce the not inconsiderable mortality of this condition and it is for this reason that it seemed justifiable to put on record 30 cases seen personally by the author and the results obtained in 25 of these, following operation.

An analysis of the primary lesions causing subphrenic abscess is shown in Table I.

TABLE I. PRIMARY LESION LEADING TO SUBPHRENIC ABSCESS

Duodenal ulcer perforation (sutured)	9
Leak or suspected leak from duodenal ulcer	6
Acute appendicitis (appendectomy)	3
Acute cholecystitis or gallstones	3
Wounds in region of liver	3
Boils or carbuncles	2
Postcholecystectomy	1
Postgastrectomy	1
Liver abscess	1
Puerperal sepsis	1
Total	30

It will be noted that nearly one-third of the cases followed the closure of a perforated duodenal ulcer, and one-half, if one adds to these, the cases in which a duodenal ulcer had leaked or was suspected to have leaked. Three abscesses followed acute appendicitis, in spite of appendectomy, and three were associated with acute cholecystitis or cholelithiasis. A further 3 cases resulted from war injuries to the liver; one of these patients was a naval rating, serving on an aircraft carrier, who was hit in the abdomen by the wing of a landing airplane and sustained rupture of the liver. Two cases gave a history of recent boils or carbuncles. Failure to inquire about this type of recent infection may account for some of those reported cases in which no cause for the subphrenic abscess was found. One case each occurred following cholecystectomy, gastrectomy, liver abscess, and puerperal sepsis.

The abscess may develop within a few hours of the onset of the primary lesion or it may be of quite insidious onset and only diagnosed after many

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months. Three of the abscesses had been present for over six months and one of these followed appendectomy two years previously. This chronicity of some cases is well known to surgeons familiar with subphrenic abscess.

The pus obtained in one-third of the cases gave a growth of *Staphylococcus aureus;* in one-third, hemolytic streptococcus, in rather less than a third, *Bacillus coli;* and, in the remainder, a combination of two of these organisms.

Symptomatology.—In the common right-sided subphrenic abscess the patient will complain of right posterior lumbar pain and less commonly of pain in the right hypochondrium. In the infrequent occurrence of a left-sided subphrenic abscess, the pain will, of course, be left sided—left upper abdominal if more anterior, left posterior lumbar if more posterior. Only 4 cases in this series were left sided. Sometimes shoulder tip pain is present. Breathlessness may be a feature and results from elevation of the diaphragm restricting the aeration of the lower lobe of the lung. Cough was present in some of the cases. Sputum may be profuse if failure to drain the abscess has allowed it to rupture through the diaphragm into the lower lobe of the lung. There may be a recent history of upper abdominal pain or recent operation on the stomach, duodenum, gall bladder, or appendix.

Clinical Signs.—These are characterized by a persistent pyrexia accompanied by an increased respiratory rate; or an elevation of temperature and respiratory rates, three or four days after an operation for, say, the closure of a perforated duodenal ulcer. Tenderness will be present over the twelfth rib and/or below the costal margin. The right lower chest will show diminished movement and there will be impairment to percussion or frank dullness over the right lower lobe while the area of liver dullness may be increased. A discharging upper abdominal wound may be present as a silent witness of a recent operation in which all has not gone well.

X-ray investigation is most helpful. The cardinal findings are elevation of the diaphragm and diminished diaphragmatic movement. Harley (1949)[1] stresses the point that in left-sided subphrenic abscess the mobility of the spleen, stomach, etc., is such as to allow the abscess to enlarge downward; in consequence, elevation of the left diaphragm is much less than in right-sided abscesses. He also makes the useful point that, in right-sided subphrenic abscess, a rise on the right side is an accentuation of the normal elevation and is, in consequence, more obvious. A gas bubble is commonly present under the diaphragm, particularly following the perforation of an abdominal viscus. X-ray films taken of the patient lying on his side will confirm the presence of a fluid level in the abscess. Most patients have a trace of fluid in the costophrenic angle and some may have a quite moderate effusion. As a rule the lower lobe is partly or completely atelectatic and on occasions it is consolidated.

CASE REPORTS

CASE 1.—The patient had a partial gastrectomy in another hospital three weeks prior to admission to the thoracic unit. Closure of the duodenum had been difficult and the stump leaked on the second postoperative day. At this time, he had developed pain under the right costal margin and he had been tender and guarded in this area. On the third day, he had had pain and tenderness over the right lower ribs posteriorly and by this time he

was running an intermittent pyrexia which responded, only for a time, to penicillin. There were dullness and diminished movement over the right lower lobe. The x-ray films showed elevation of the right diaphragm over a gas bubble; the lower and middle lobes were partly atelectatic (Figs. 1 and 2). This patient was drained anteriorly and Fig. 3, taken some days later, shows the drainage tube in situ with Lipiodol instilled.

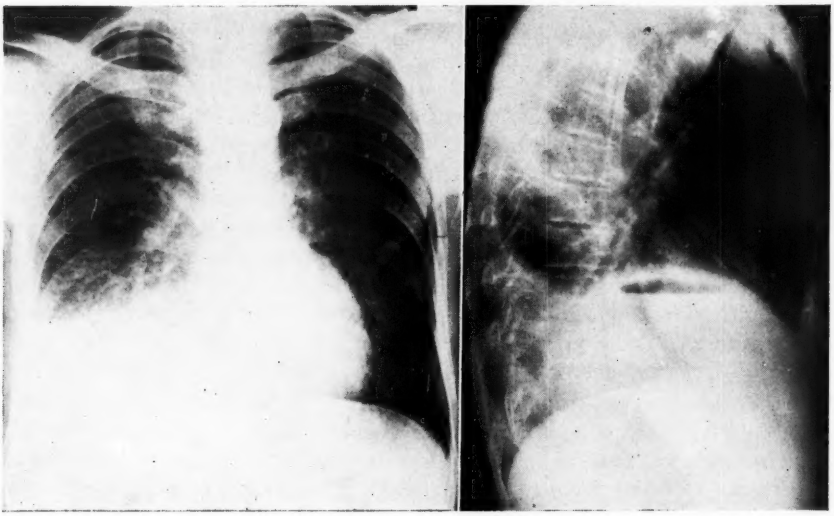

Fig. 1. Fig. 2.

Figs. 1 and 2.—Case 1. Elevation of the right diaphragm over a gas bubble. There is partial atelectasis of the lower and middle lobes.

Fig. 3.—Case 1. Lipiodol filled drainage tube several days after operative drainage by the anterior route.

CASE 2.—The patient, a 76-year-old man in poor general condition, was admitted with right upper abdominal pain which was thought to be due to acute cholecystitis. At operation pus was obtained from the subphrenic space in the region of Morison's pouch (Figs. 4 and 5).

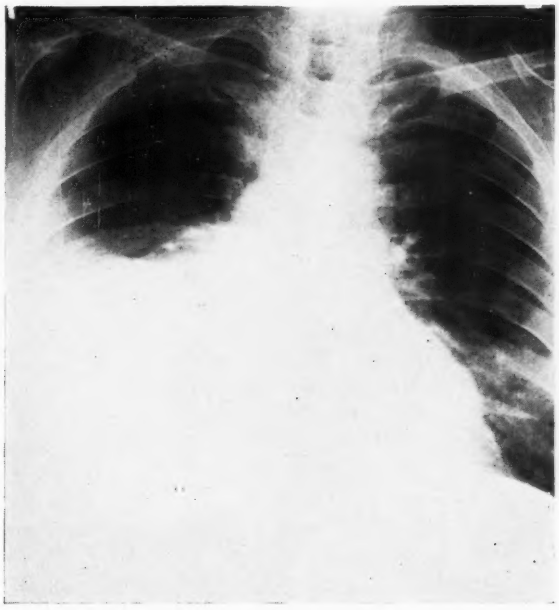

Fig. 4.

Fig. 5.

Figs. 4 and 5.—Case 2. Marked elevation of the diaphragm in subphrenic abscess resulting from acute cholecystitis.

Fig. 6.

Fig. 7.

Figs. 6 and 7.—Case 3. Marked elevation of diaphragm due to a subphrenic abscess developing subsequent to the operation of cholecystectomy.

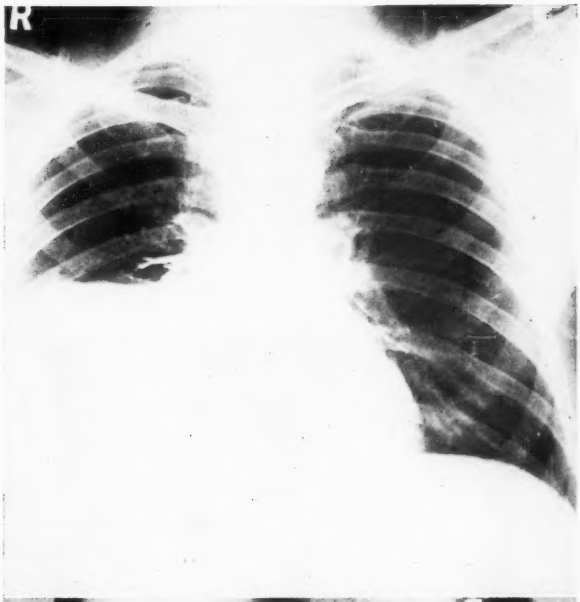

Fig. 8.

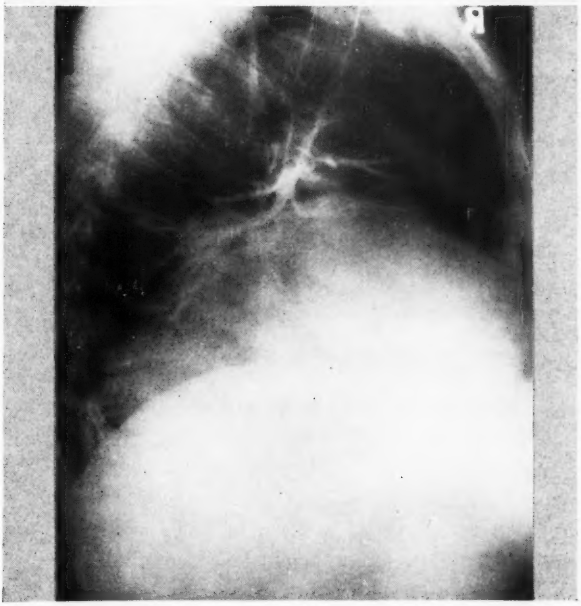

Fig. 9.

Figs. 8 and 9.—Case 3. Bronchogram confirms the elevation of the diaphragm and shows the upward displacement of the atelectatic lower and middle lobes.

CASE 3.—This patient, a 42-year-old man, had had a cholecystectomy in another hospital ten months prior to admission to the thoracic unit. He had had a stormy convalescence and the wound burst. The right lung collapsed and he had developed a pleural effusion. Six months later, he developed recurring fever, and pain in the right upper quadrant of the abdomen, accompanied by shoulder tip pain. One month prior to transfer to the thoracic unit, an attempt was made to drain the abscess but only a little pus was obtained. Posteroanterior and lateral x-ray films showed a very high diaphragm with collapse of the middle and lower lobes of the lung (Figs. 6 and 7). In this type of chronic case, the diagnosis may be difficult and, if doubt exists, bronchography will make the situation abundantly clear as to whether the shadow is, in fact, due to a raised diaphragm or not (Figs. 8 and 9). Three and one-half pints of pus were emptied from this abscess and Fig. 10 shows Lipiodol instilled into the sinus some days after drainage by the standard posterior approach.

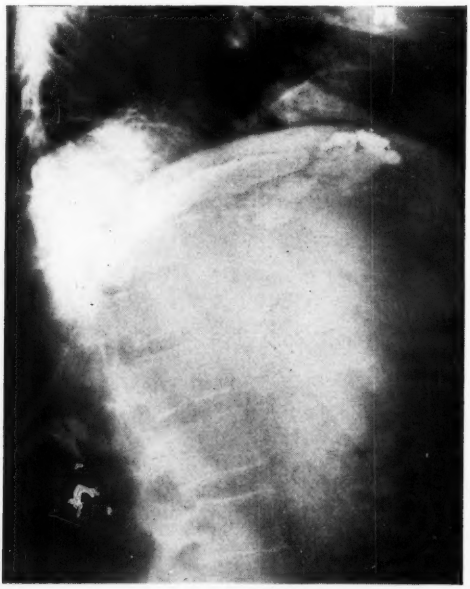

Fig. 10.—Case 3. An x-ray which shows Lipiodol instilled into the posteriorly placed drainage wound.

Treatment.—One agrees with Hunt (1948)[2] that diagnostic aspirations should be avoided for fear of spreading infection to pleura or peritoneum. Operation to establish drainage should be performed if the subphrenic abscess is of any size and if, in spite of antibiotic treatment, the pyrexia continues and is accompanied by pain and tenderness. The usual posterior incision is made over the twelfth rib and a sufficient length of the rib is excised to allow the operator's hand to enter the wound. If the pleural reflection presents, it is displaced upward and the diaphragm is traversed, the upper surface of the liver being easily reached. A very wide stiff drainage tube is used and should be left unshortened for several days. The posterior approach has the advantage of being extraserous and of giving dependent drainage to a patient in

the sitting-up position; it also has the merit of a mortality rate of nearly half that of drainage by the transserous route (Harley, 1949). On rare occasions when the abscess is obviously presenting anteriorly, drainage from the front may be preferred.

RESULTS

Table II shows the results in the 30 cases of this series. It will be seen that subphrenic abscess is a condition which carries quite a fair mortality. In 25 cases drainage was used, 3 of these patients died, giving a mortality of 12 per cent. In 5 patients, drainage was never established and, of these, 2 died, giving a mortality of 40 per cent. In the total of 30 cases there were five deaths—an over-all mortality of 16.6 per cent.

TABLE II. THE OUTCOME IN 30 CASES OF SUBPHRENIC ABSCESS

	NUMBER OF CASES	NUMBER OF DEATHS	MORTALITY (%)
Evacuation of abscess and drainage	25	3	12
Not drained	5	2	40
Total of 30 cases with 5 deaths			16.6

In the series of 182 cases collected by Harley (1949), the mortality for the cases in which drainage was used was 26.6 per cent, and for those without drainage, 83 per cent, giving an over-all mortality of 40.1 per cent. While the figures in this series compare very favorably with the collected series of Harley (1949), the mortality is still far too high.

Of the five deaths, four resulted largely because the diagnosis was delayed too long and the provision of drainage was either inadequate or too late. Admittedly, 2 of these patients were old men in their middle seventies, but one was a healthy man, aged 25, in whom the diagnosis was so protracted that metastatic brain abscesses developed and drainage was never established.

The fifth case was masked in that the perforation of the duodenal ulcer occurred into the lesser sac.

CONCLUSION

It is generally true to say that it is only necessary for the thoracic surgeon to hear the clinical history of a case to be able to suggest the diagnosis. Subphrenic abscess should be suspected in any patient recently submitted to an upper abdominal operation, particularly a perforated peptic ulcer, if he has continuing upper abdominal and low back pain accompanied by swinging temperature. It is my experience, however, that surgeons, particularly general surgeons, are not sufficiently aware of the possibility and frequency of the occurrence of this complication. Also, once having made a firm diagnosis of subphrenic abscess, they are very liable to hold a "watching brief" over what may well turn into "watching disaster." Delay in treatment or failure to achieve adequate drainage by anterior or lateral approach my well result in the abscess bursting through the diaphragm, with consequent bronchiectasis. Delay, as we have seen, may result in the patient's death.

Subphrenic abscess should be thought of if the circumstances just discussed are found, examination and investigation for it ought to be instituted, and radical drainage should be established forthwith if the abscess is of large dimensions or is found to be unresponsive to early conservative treatment.

It is true to state in this complication of subphrenic abscess as in all conditions in which a serious or even fatal complication may occur—there is some excuse to have looked and found nothing, there is no excuse for not having looked at all.

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INTRATHORACIC LIPOMAS

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JUDGING from the number of cases reported in the literature, the care of 2 patients with an intrathoracic lipoma during a five-year period by a single individual would be an unusual circumstance. Keeley and his associates[1] gathered 57 cases from the literature and added a case of their own. Since that time, 8 cases have been added,[2-9] bringing the total to 66. In this communication, 2 cases of intrathoracic lipoma are presented† along with a brief discussion of the tumor.

CASE REPORTS

CASE 1.—L. H., a 32-year-old Negro man, was first seen in January of 1950 because an abnormality of the right lung field had been detected three months previously on a routine chest x-ray. He was without symptoms and gave a history of smoking one package of cigarettes daily.

No abnormalities were demonstrated on physical examination and, except for a moderate anemia, all laboratory reports were normal. Roentgenograms of the chest (Fig. 1) showed a semicircular mass overlying the upper right lung posteriorly. The roentgenologist's impression, after reviewing the stereoscopic films, was that the mass lay in an extrapleural position, located in the soft tissues along the medial border of the scapula.

Following correction of the anemia, exploratory thoracotomy was carried out six days following admission. Elevation of the scapula revealed no evidence of the tumor mass between it and the thoracic cage as had been indicated by the roentgenologist. When an intercostal incision was made between the fourth and fifth ribs and the pleura opened, a soft cystic tumor about the size of a hen's egg was found in the pleural space adjacent to the fifth rib and the posterior axillary line. Clinically and histologically, the tumor was a lipoma. The tumor was excised and the patient recovered uneventfully (Fig. 2) and is in good health four years following operation.

CASE 2.—V. A., No. 61018, a 55-year-old Negro man, was admitted to the Veterans Hospital Jan. 29, 1955, complaining of chronic cough, wheezing, shortness of breath, and a slightly productive cough of several years' duration. He had been investigated in 1949 because of recurring precordial pains with radiation to the right shoulder and right arm. However, no abnormalities were demonstrated at this time and he was discharged without a positive diagnosis.

Physical examination on the present admission revealed slight dyspnea at rest and a pulse rate of 92 per minute. In addition, dry expiratory wheezes were heard over the lower lung fields, bilaterally. A routine chest film (Fig. 3) revealed a large ovoid density in the left base, projecting approximately 2 cm. above the level of the diaphragm. Fluoroscopic examination showed the mass to lie far posteriorly in the costophrenic sinus. It was suggested at that time by the roentgenologist that the mass might represent a herniation of a subdiaphragmatic organ and, for that reason, additional roentgenograms following pneumoperitoneum were obtained, demonstrating the mass to be attached to the diaphragm and to lie above the diaphragm (Fig. 4). It was thought by the roentgenologist

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†Case 1 previously reported. The Surgical Management of Intrathoracic Lesions, The Mississippi Doctor 31: 387, 1954.

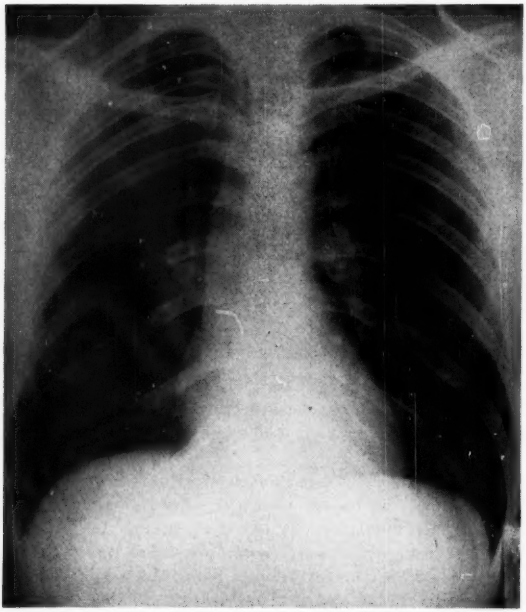

Fig. 1.—Smooth-rounded density overlying right anterior first and second ribs.

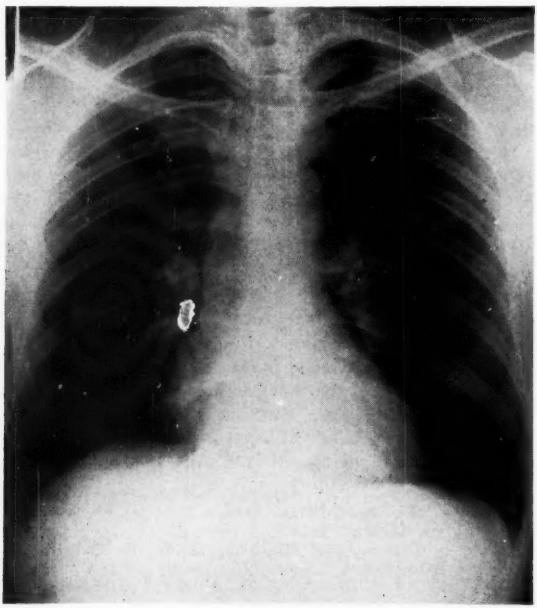

Fig. 2.—Postoperative film.

Fig. 3.

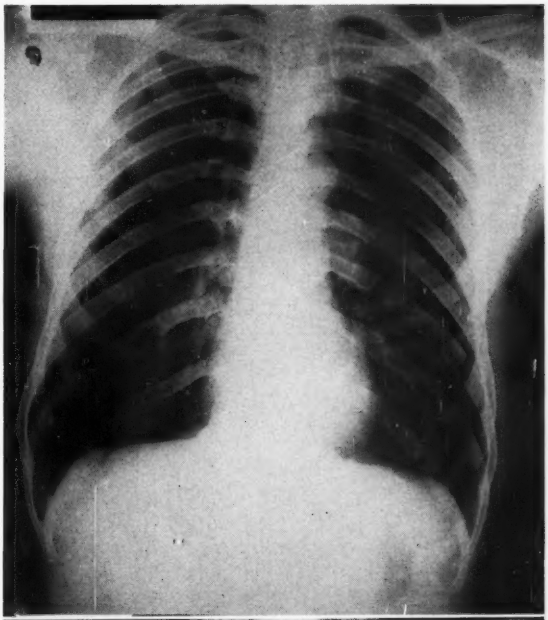

Fig. 4.

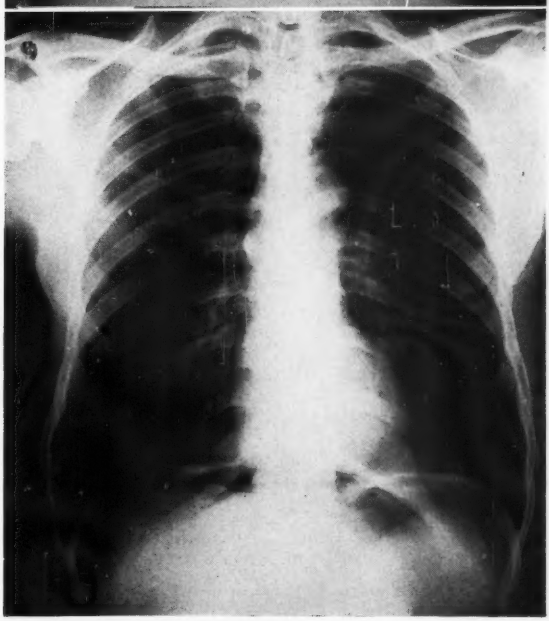

Fig. 3.—Rounded density projecting above diaphragm in left cardiophrenic angle.
Fig. 4.—Following pneumoperitoneum.

Fig. 5.

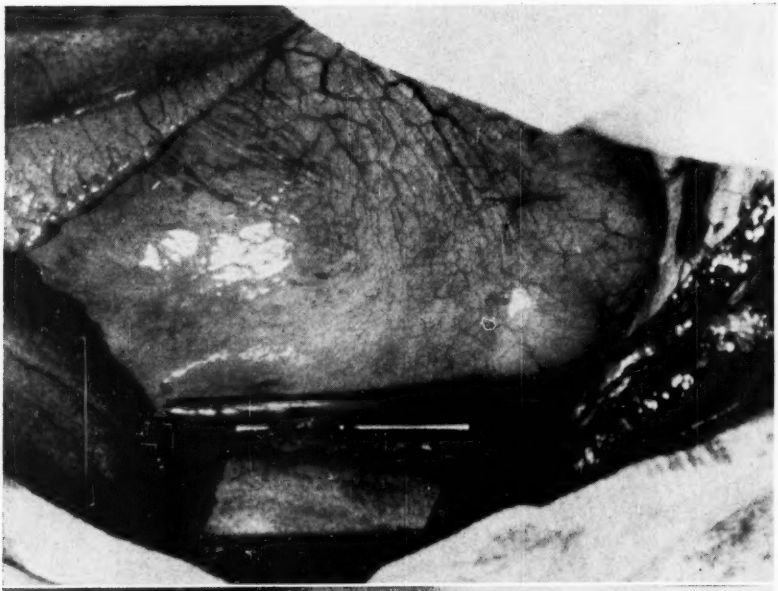

Fig. 6.

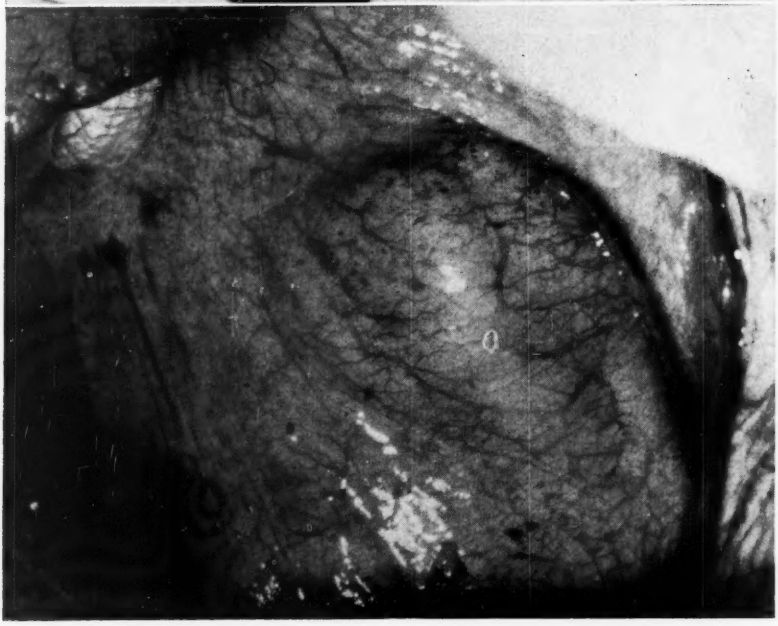

Fig. 5.—Smooth-rounded tumor in posterior medial part of diaphragm.
Fig. 6.—Same as Fig. 5, but with diaphragm retracted anterior and laterally.

that the mass represented a benign tumor, most likely a lipoma. Because of the unknown nature of the tumor, the left chest was explored through the bed of the resected eighth rib. A 7 cm. tumor, having all the characteristic appearances of a lipoma, was easily demonstrated in the costophrenic sinus at the most posterior part of the left diaphragm (Figs. 5 and 6). After the pleura overlying the tumor had been incised, it was demonstrated that the lipoma arose from the properitoneal fat and extended through the diaphragm, separating the muscle fibers of that structure. The tumor was excised and the diaphragm repaired. The postoperative course was uncomplicated except for accumulation of fluid following removal of the thoracotomy tube. This was corrected by two aspirations and the patient was discharged with essentially the same symptoms as he presented on admission.

DISCUSSION

The classifications of lipoma previously proposed have been related to the anatomic site of the tumor.[1]

1. Intrathoracic lipomas: those lying entirely within the thoracic cage.
2. Hourglass thoracic lipomas: those having both intra- and extrathoracic portions.
   a. Cervicomediastinal; passing from the mediastinum into the neck.
   b. Transmural; passing through the chest wall—usually an intercostal space, rarely through the sternum.

In addition to these locations, lipomas may arise intrabronchially[10, 11] and from the external surface of the heart.[12] In addition to this anatomic classification, a histologic one might be considered, although this would necessarily include cases other than pure lipomas such as we are presenting here. This classification would include liposarcomas,[13] hibernomas,[14] and the somewhat controversial thymolipomas.[15] Rubin and Mishkin[15] have suggested that thymolipomas are actually lipomas per se which have their origin in thymus gland fat and carry remnants of the thymus with it as the bulk and weight of the tumor cause it to gravitate to the more inferior confines of the mediastinum.

The symptoms and physical findings presented by the patient depend upon the size and location of the tumor and, as would be expected, asymptomatic lipomas are frequently discovered on routine chest films. When this is the case in the differential diagnosis, one should keep in mind that lipomas have been confused with cardiac enlargement[8] and, in addition, they must be differentiated from those tumors which frequently arise in the location occupied by the lipoma in question. Keeley[1] pointed out that the good general condition of the patient with a lipoma of such size and configuration as to represent a far-advanced malignant process on chest x-ray was an important point in the differential diagnosis of the tumor. In addition, Heuer and Andrus[16] have described the x-ray of intrathoracic lipomas as being characteristic, suggesting that the difference in specific gravity between fat and fluid produces a relatively clear peripheral zone in the lipoma which is not found in fluid. Other diagnostic measures which have been employed include pneumothorax, pleuroscopy, and needle aspiration. The use of pneumoperitoneum in our second case was useful in differentiating the tumor of the diaphragm from a diaphragmatic hernia.

Despite the many diagnostic aids at our disposal, it is frequently impossible to determine which tumors are lipomas and which are not. Along this

line, it is interesting to note the reported number of cases of liposarcoma and to compare that figure with the number of lipomas found in the literature. Storey and Knutson[13] gathered from the literature five solitary liposarcomas of the mediastinum and 5 cases of multiple liposarcomas. When these 10 cases of liposarcoma are numerically compared with the 57 cases of lipoma which had been reported at about that time, one wonders whether the incidence of sarcomatous degeneration in a thoracic lipoma may be higher than in other locations. However, it may well be that these figures are distorted by the fact that asymptomatic intrathoracic lipomas are not discovered and, hence, do not find their way into the literature.

In any event, the treatment of choice is exploratory thoracotomy and excision of the tumor. Once the chest is open and the tumor is in view, there is usually little difficulty in identifying the lipoma as such and affecting its removal. When dealing with especially large lipomas, or other bulky intrathoracic tumors for that matter, it must be appreciated that compensatory space adjustments have occurred during the slow growth of the tumor.[17, 18] When the pleural cavity is opened, these compensatory adjustments are disturbed and potentially lethal cardiorespiratory problems arise which must be immediately recognized and rapidly corrected.

SUMMARY

Two cases of unusually located intrathoracic lipomas are reported and the subject briefly discussed.

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BRONCHOPULMONARY SEQUESTRATION

Some Clinical Aspects with Report of Six Cases

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SINCE 1951, 6 cases of intralobar bronchopulmonary sequestration have been diagnosed and operated upon at Fitzsimons Army Hospital. These congenital lesions occurred in young soldiers varying in age from 17 to 24, and 5 of the 6 cases were asymptomatic. Nevertheless, it has been stated that most patients with that condition give a history of repeated pulmonary infections with chills, fever, productive cough, and roentgenographic abnormalities in the lower lung fields.[1]

This condition has received a great deal of attention in the medical literature since 1946 when Pryce published his first paper on the subject.[2] Anomalous arterial supply to the lungs, however, was first described in 1802 by Maugars, a French medical student.[3] Descriptions of surgical procedures in over 100 cases have appeared in the literature. This entity is important to the surgeon because it represents a hazard to those not familiar with the condition; under such a circumstance, technical difficulties may arise as dissection is performed in the vicinity of the anomalous artery. No technical errors have occurred during the surgical treatment of our small series of patients—due largely to the roentgenographic findings and diagnostic implications. Excellent reviews of this interesting anomaly have been published since 1950 by Bruwer,[1] Wyman,[4] Boyd,[5] and Cole,[6] and their associates. The reader is referred to these publications for detail concerning the embryology, pathogenesis, and pathology.

The purpose of this paper is to report 6 more cases of intralobar sequestration, 5 of which were discovered by routine roentgenograms. The diagnosis was established in one case by retrograde aortography. Three of the 6 cases were seen within a period of five months in 1955. We wish to stress the importance of laminagraphy as an additional diagnostic aid and to re-emphasize that this condition probably exists in the asymptomatic state more often in young adults than in the symptomatic state.

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CASE REPORTS

CASE 1.—A 21-year-old white enlisted man was transferred to Fitzsimons Army Hospital on April 7, 1951, with a diagnosis of cystic disease of the lung. His symptoms began in March, 1951, and consisted of the sudden onset of right-sided chest pain which was aggravated by deep breathing and lying on the right side. He had suffered from a mild upper respiratory infection for one week prior to the onset of acute symptoms. He was admitted to a local station hospital where his temperature was 100.6° F. Physical examination was negative except for dullness, decreased breath sounds and râles at the right lung base. A chest roentgenogram (Fig. 1) revealed a large area of radiolucency at the right base with two fluid levels. On the second hospital day he developed a cough productive of one-half cup of greenish-yellow sputum. Antibiotic treatment was instituted and symptomatic improvement was noted in forty-eight hours. He became afebrile in two weeks and was transferred to Fitzsimons Army Hospital.

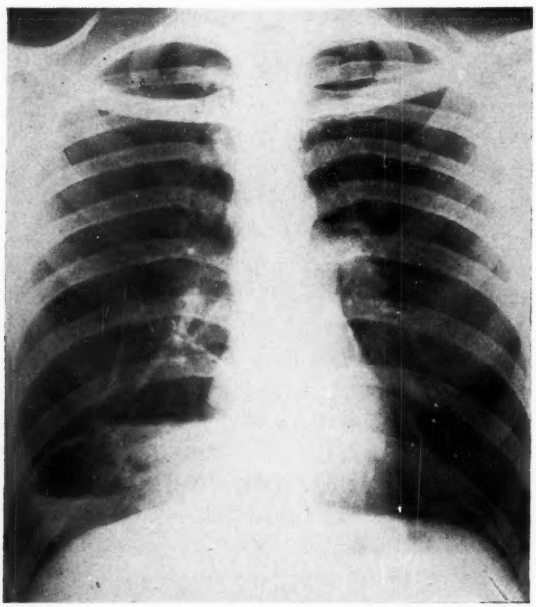


Fig. 1.—Posteroanterior roentgenogram of the chest. The enormous cyst with two fluid levels is demonstrated on the right.

The past history revealed that he had had bilateral pneumonia in 1947.

The physical examination revealed a well-developed, well-nourished white man who did not appear acutely ill. The temperature, pulse rate, and blood pressure were normal. The only positive physical findings were confined to the chest which revealed diminished breath sounds, dullness to percussion, and râles at the right base, posteriorly.

The laboratory studies were all within normal limits.

A chest roentgenogram revealed two cysts in the posterobasal and superior segmental areas of the right lower lobe with fluid levels.

At operation, the basal segments of the right lower lobe were replaced by cystic changes. The entire lower lobe appeared grossly free of anthracotic pigment. In the

inferior pulmonary ligament, a large artery was noted to enter the thoracic cavity through the diaphragm and enter the lower lobe. A right lower lobectomy was performed without complications.

At gross pathologic examination, multiple cysts filled with gelatinous material were found. There were no demonstrable bronchial communications with these cysts. The anomalous artery measured 6 mm. in diameter and supplied the cystic portions of the lung. Microscopic examination revealed that the cysts were lined by columnar-type epithelium. The pulmonary parenchyma showed remnants of alveolar architecture; considerable fibrosis and other chronic inflammatory changes were noted.

CASE 2.—A 24-year-old Negro corporal was transferred to Fitzsimons Army Hospital on Dec. 9, 1952, with an undiagnosed mass in the left lung.

The patient had been entirely asymptomatic and a routine physical examination and chest roentgenogram in September, 1952, revealed a homogeneous rounded mass in the left lower lung field. The past medical history was negative and there was no history of pneumonia. The physical examination was within normal limits.

The laboratory findings revealed that the hemogram, the urinalysis, and the sedimentation rate were normal. Tuberculin test (purified protein derivative No. 1) was positive. The histoplasmin and coccidioidin skin tests were slightly positive. Culture of the sputum and gastric contents for acid-fast bacilli was negative on several occasions.

A chest roentgenogram revealed a 2 cm. rounded mass of homogeneous density in the medial portion of the lower lung field on the left (Fig. 2). A lateral x-ray localized this area to the posterobasal segment. Review of x-rays which were taken prior to this patient's induction into military service revealed that this lesion had been present since November of 1950 and had been unchanged since that time. A bronchogram demonstrated the presence of a large emphysematous area with distortion and displacement of all basilar bronchi (Fig. 3).

A diagnostic thoracotomy was performed on March 19, 1953. The lateral and posterior basal segments of the left lower lobe appeared pink and showed no visible anthracotic pigment. Located in the upper portion of the lateral and posterior basal segments was a cystic mass which measured approximately 3 cm. in its greatest diameter. In the pulmonary ligament, an artery was discovered which came from below the diaphragm and measured 5 mm. in diameter. A left lower lobectomy was performed without complications.

On gross pathologic examination the posterobasal segment was noted to be quite pink and devoid of visible anthracotic pigment. A 3 cm. mass was palpated in the posterior aspect of the posterobasal segment. In the medial portion of the posterobasal segment, a large 3 cm. cystic mass was demonstrated and was filled with a greenish-gray mucoid material. There was no bronchial communication. An anomalous artery was noted to run just lateral to the cystic mass and divide into several branches in that area. The cyst was irregular and possessed a very thin, grayish-white wall.

Microscopic examination revealed that the cyst was lined with columnar-type epithelium and the pulmonary parenchyma revealed evidence of fibrosis and inflammation.

CASE 3.—A 22-year-old white male sergeant was admitted to Fitzsimons Army Hospital on Nov. 27, 1953, for evaluation of an infiltrate in the right lower lobe.

The present illness began in October, 1953, and was characterized by an upper respiratory infection which was associated with a mild cough productive of small amounts of white sputum with occasional streaking of blood. This infection lasted for approximately two weeks. The patient was treated with penicillin and Aureomycin which caused a disappearance of all his symptoms and he had remained in good health thereafter. A chest roentgenogram made at this time revealed an area of infiltration in the right cardiophrenic angle. Tuberculin (PPD) skin tests were negative. Cultures of the sputa and gastric contents for acid-fast bacilli were negative.

The past history is significant in that the patient had had two previous attacks of pneumonia, one in 1949 and one in 1950.

The physical examination was within normal limits.

Fig. 2.

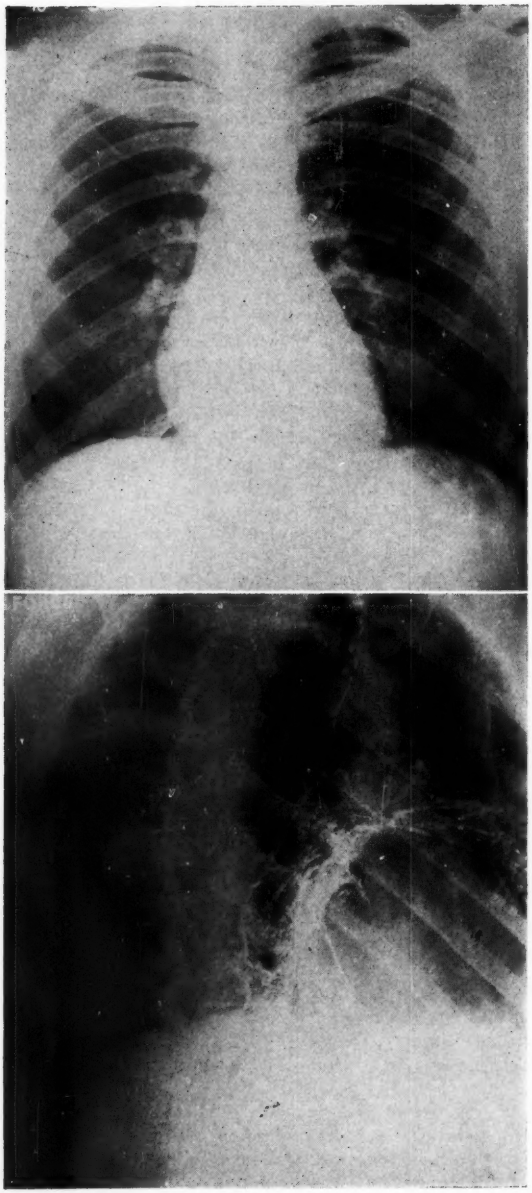


Fig. 3.

Fig. 2.—Posteroanterior roentgenogram of the chest. A rounded mass partially hidden by the left tenth rib is seen; increased radiolucency is noted below and lateral to the area of homogeneous density.

Fig. 3.—Right anterior oblique bronchographic view demonstrates a large emphysematous area not communicating with the bronchial tree and displacing all basilar bronchi. The dense mass is not shown on this view.

Additional laboratory studies, which included urinalysis, serology, and hemogram, were negative. All of the skin tests, tuberculin (PPD), histoplasmin and coccidioidin, were negative. A chest roentgenogram revealed a sharply demarcated lobular area of increased density which was quite homogeneous in the right lung field, located in the region of the cardiophrenic angle (Fig. 4). Roentgenograms of chest obtained prior to induction into the military service were reviewed and this lesion had been present since that time without change. A bronchogram demonstrated incomplete filling of the posterior basal segmental bronchi.

An exploratory thoracotomy was performed on Feb. 8, 1954, and a large cystic mass was palpated in the posterolateral and posterior basal segments. An anomalous artery measuring 8 mm. in diameter and 4 cm. in length was found in the free edge of the inferior pulmonary ligament. Its origin was from the aorta. The anomalous artery entered the area of the cystic change in the lower lobe. A right lower lobectomy was performed. There were no postoperative complications.

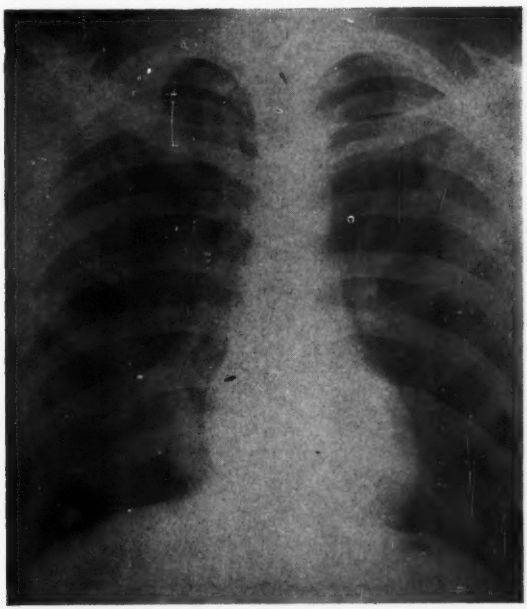
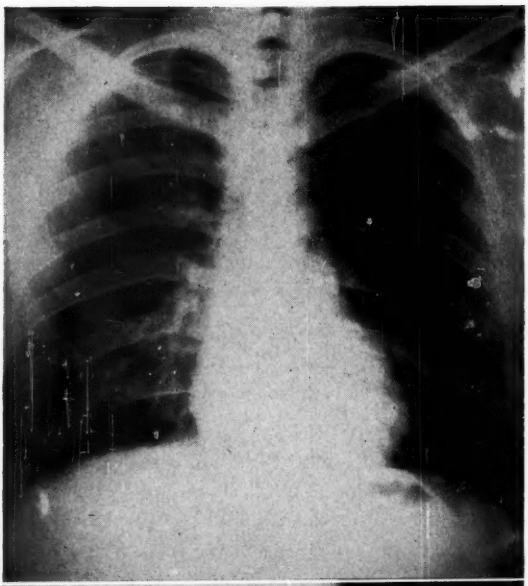


Fig. 4.—An area of increased density, fairly well demarcated, is visualized near the right cardiophrenic angle.

Gross pathologic examination revealed a cystic mass which measured 11 by 7 by 5 cm. in the area of the posterior and lateral basal segments. The cyst contained a grayish-brown grumous material which resembled an old blood clot. There was no bronchial communication between the cystic area and the normal bronchial tree. A large artery which measured 8 mm. in diameter entered the cystic mass and gave off numerous ramifications into the substance of the involved segment and about the walls of the cyst. One of the branches of this abnormal artery converged upward toward the hilum and anastomosed with a branch of the pulmonary artery.

Microscopic examination demonstrated the cyst to be lined by low columnar and cuboidal ciliated epithelium. The pulmonary parenchyma showed a mild degree of chronic organizing pneumonitis with mild inflammatory changes. A section of the large aberrant artery showed that it was of the elastic type. There were no atheromatous deposits found on the intima.

Fig. 5.



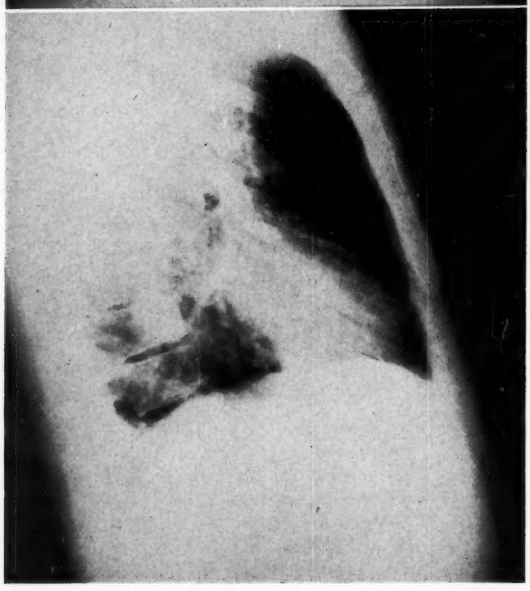


Fig. 6.

Fig. 5.—Roentgenogram demonstrates irregularly outlined area of density in the medial portion of the right lower lung field.

Fig. 6.—Circumscribed area of density localized to the area of the posterior basilar segment on lateral laminagraphic view.

CASE 4.—A 23-year-old white man was transferred to Fitzsimons Army Hospital on June 6, 1955, for evaluation of an abnormal chest roentgenogram which was obtained in May, 1955.

The patient had been hospitalized elsewhere for treatment of a peptic ulcer. A chest x-ray obtained in May, 1955, revealed an ill-defined infiltration in the lower portion of the right lung field.

The past history was completely negative.

A complete physical examination was within normal limits.

Laboratory examinations which included a complete blood count, urinalysis, and serology were normal. A culture of the sputa for predominating organisms revealed alpha and beta hemolytic streptococci and *Neisseria catarrhalis*. The tuberculin skin test (PPD), intermediate strength, was positive. The histoplasmin and coccidioidin skin tests in a dilution of 1:100 were negative. A bronchoscopic examination showed mucopurulent tenacious secretions coming from the orifice of the right lower lobe. A chest roentgenogram (Fig. 5) made in June, 1955, demonstrated a homogeneous density in the medial portion

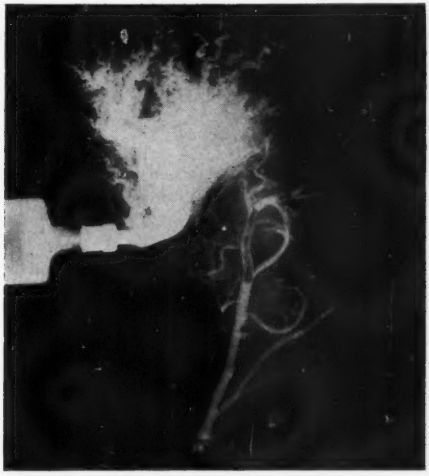


Fig. 7.—Roentgenogram of surgical specimen. The aberrant artery is incompletely filled with Lipiodol. The basilar bronchi are filled with the same contrast medium and attached to syringe.

of the right lower lung field with a sharp superior and lateral margin but an indistinct inferior and medial margin. Laminagrams revealed a loubulated density with clear-cut margins in the right cardiophrenic angle which was thought to have a stringlike density extending downward and medially toward the diaphragm. A lateral laminagram revealed that this mass lay in the posterobasal segment (Fig. 6). An angiocardiogram was normal. Anterior displacement of the posterior basal segmental bronchi was demonstrated by bronchography. By retrograde aortography, a vessel was seen to arise from the right side of the aorta and extend up into the base of the right lung, supplying the area of increased density in the medial and posterior portion of the right lung field.

On Aug. 8, 1955, an exploratory thoracotomy was performed. The posterior one third of the right lower lobe was light pink in color. There was no anthracotic pigment visible. Palpation of this area revealed the presence of a comma-shaped, rubbery, fluctuant density which measured approximately 5 by 4 by 3 cm. An aberrant artery was noted in the inferior margin of the pulmonary ligament which measured 6 mm. in diameter and originated from the aorta at the level of the right leaf of the diaphragm. This artery measured 3.5

cm. in length and entered the substance of the lung posteriorly in the region of the posterobasal segment. Resection of the basilar segments of the right lower lobe was performed without complication.

On gross pathologic examination, in the region of the posterobasal segment, a fluctuant mass was palpated which measured 4 by 3 by 2.7 cm. Approximately 20 c.c. of a creamy, tenacious, semisolid material was found within the cystic mass. An anomalous artery was found to enter the posterior and medial basal segments, which was approximately 5 mm. in diameter and seemed to encircle the cystic area in the posterobasal segment. There was no bronchial communication demonstrable (Fig. 7).

Microscopic examination revealed that the cyst was lined by ciliated columnar epithelium. In some areas cartilaginous plates were found. Within the pulmonary parenchyma a moderate amount of fibrosis and inflammatory reaction was noted. Sections through the anomalous artery revealed that there was an abundance of elastic tissue within the media. Atheromatous plaques were found in the intima in many sections.

CASE 5.—A 22-year-old white enlisted man was admitted to Fitzsimons Army Hospital on Oct. 10, 1955, for evaluation of an infiltrate in the lung of undetermined etiology.

In September, 1954, during basic training this patient suddenly developed a fever and cough productive of small amounts of purulent sputum. He was hospitalized at the local station hospital and treated for a period of two weeks. He recovered completely from this episode and was symptom free until August, 1955, at which time he noted the onset of ease of fatigue and a 15-pound weight loss which occurred over a period of one month.

The past medical history was completely negative.

The physical examination was within normal limits.

Laboratory studies revealed that the blood count, sedimentation rate, urinalysis, serology, and all of the skin tests to be negative. Gastric washings and culture for acid-fast bacilli were negative.

Chest roentgenograms made in September, 1954, revealed an increased density in the medial portion of the right lower lung field. Chest x-rays taken at Fitzsimons Army Hospital demonstrated an oblongated mass in the right lower lung field on posteroanterior view, which was localized to the posterobasal segment of the right lower lobe on lateral chest roentgenograms (Fig. 8). There was some suggestion of a cystic area peripheral to the homogeneous mass. Posteroanterior and lateral laminagrams showed that this was a "comma-shaped" density and that there was a suggestion of a vessel in the medial and inferior portion of this mass which extended downward toward the diaphragm. Peripheral to the homogeneous mass, an emphysematous area was noted which had the appearance of a pulmonary cyst. An angiocardiogram was within normal limits. Complete filling of all segments of the right lung except the superior segmental bronchus was demonstrated by bronchography (Fig. 9). A large cystic area occupied the region of the superior segment. A retrograde aortogram did not reveal any abnormal vessels entering the lung.

On Dec. 6, 1955, an exploratory thoracotomy was performed. In the region of the posterobasal segment the lung appeared quite pink and was without evidence of anthracotic pigmentation. A cyst which measured 5 by 4 by 3 cm. was palpated in this area. Just superior to the inferior pulmonary vein and along the course of the lower lobe bronchus, a large bronchial artery measuring 2.5 mm. in diameter was found which came directly up through the mediastinum from the aorta. This large systemic artery was observed to enter the substance of the emphysematous tissue and the cystic area in the posterobasal segment. Resection of the palpable, irregular cyst along with the attached posterior basal segment and the emphysematous parenchyma in the anatomic location of the superior segment was performed without undue difficulty.

On gross pathologic examination, numerous intercommunicating cystic structures varying in size from 1 to 4.5 cm. were observed in the region of the posterobasal segment. There was no bronchial communication to these cystic areas. A large anomalous artery measuring 3 mm. in diameter was found to enter the region of the posterobasal segment. There were two small branches of the pulmonary artery which entered the abnormal sequestered pulmonary tissue in the superior segment.

Fig. 8.

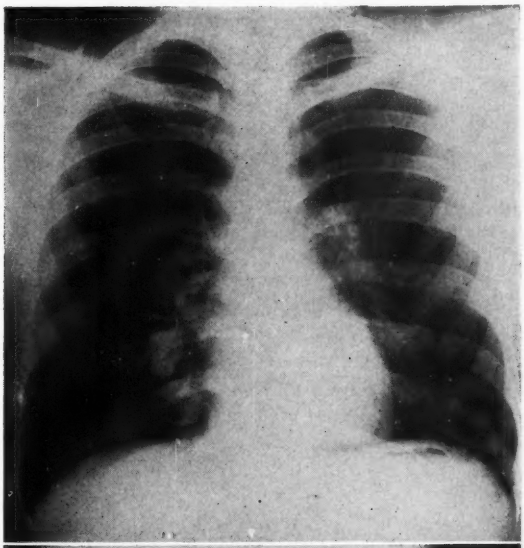


Fig. 9.

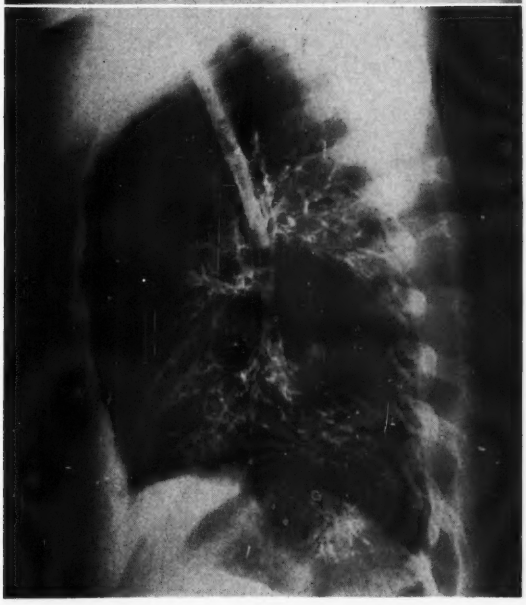


Fig. 8.—Roentgenogram of the chest. Area of density clearly visualized in the medial portion of the right lower lung field.

Fig. 9.—Lateral bronchographic view. Nonfilling in the region of the superior segment of the right lower lobe; localized density again viewed in this area.

Microscopic examination revealed that these cysts were lined with bronchial-type epithelium. The pulmonary parenchyma presented evidence of pulmonary fibrosis and inflammatory changes.

CASE 6.—A 17-year-old Negro airman was transferred to Fitzsimons Army Hospital in October, 1955, because of an abnormal routine chest roentgenogram.

The patient had been completely asymptomatic until Aug. 1, 1955, at which time he developed a mild cough which was productive of a small quantity of thick sputum. There was no history of hemoptysis, nor was there any history of pulmonary infections in the past.

The past medical history was negative.

Physical examination revealed a well-developed, well-nourished Negro man who did not appear acutely or chronically ill. A complete physical examination was within normal limits.

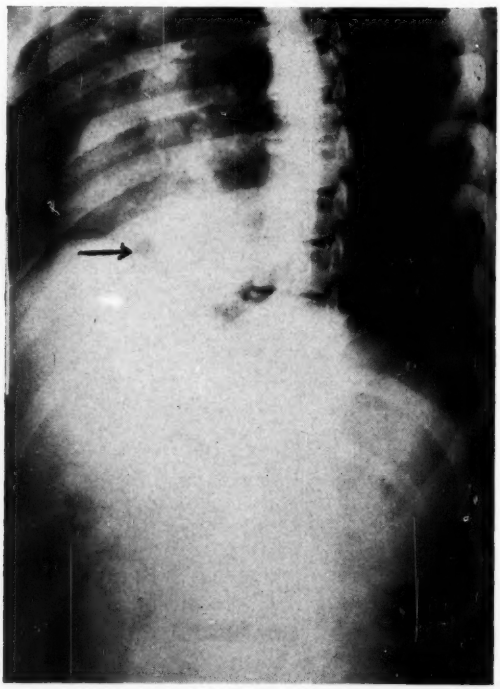


Fig 10.—Left anterior oblique roentgenogram. Arrow points to the large circumscribed homogeneous density.

The laboratory examinations revealed a normal urinalysis, blood count, and serology. The tuberculin test (PPD) was positive. The histoplasmin skin test, 1:1000 dilution, was positive.

Additional chest roentgenograms revealed an area of increased density in the right cardiophrenic angle. An upper gastrointestinal series and barium enema were within normal limits. A bronchogram was normal. Posteroanterior laminagrams demonstrated an ill-defined abnormal shadow in the right lower lung field just posterior to the right cardiophrenic angle. Lateral laminagrams and left anterior oblique views revealed a rather sharply circumscribed, rounded cystic shadow which appeared continuous with the cardiac border and was seen best on the 11 cm. through 14 cm. sections (Fig. 10). An exploratory

thoracotomy was performed on Dec. 7, 1955, and an irregular cystic mass was found in the region of the inferior pulmonary ligament and was largely located in the lower posterior mediastinum. Posteriorly, below the level of the inferior pulmonary vein, a large systemic artery coming directly off the aorta was noted. The tense cyst was excised from the mediastinal structures where it was markedly adherent to the esophagus and the inferior vena cava. The patient's postoperative course was uneventful.

Upon gross pathologic examination, an anomalous artery was seen to enter the pulmonary tissue between the posterior and medial-basal segments. A firm, irregular mass measuring 5 cm. in diameter was palpated in the mid-portion of the basilar segments. The pulmonary tissue in the medial basilar segment and the medial portions of both the anterior and posterior basal segments had a bright yellow, granular appearance.

Microscopic examination revealed that the cyst wall was lined with bronchial epithelium. Surrounding the cyst, no pulmonary parenchyma, recognized as such, was present. A marked inflammatory infiltration was found in most sections. This reaction consisted of lymphocytes, plasma cells and, in some areas, polymorphonuclear leukocytes. A large number of macrophages containing fat droplets were observed in the medial-basal segment. Most of these macrophages were within the alveolar walls. In the lateral-basal segment, more normal-appearing pulmonary tissue was seen. There were a number of these lipoid-filled macrophages in this area also, but there seemed to be a sharp line of demarcation between the more solid lipoid-filled areas and the relatively normal lung tissue.

DISCUSSION

Intralobar bronchopulmonary sequestration as demonstrated in these 6 cases presents a rather typical roentgenographic picture, but no characteristic clinical signs and symptoms. Only one of our patients was ill during the period of hospitalization, but 2 had given histories of previous pneumonia. Whether or not these were related to the sequestered areas of the lung cannot be definitely stated. We know by review of previous chest roentgenograms on 2 patients that the lesion had been present prior to induction into the military service. Both these patients' lesions had been unchanged for approximately two years prior to entry into the military service.

It is interesting to note that laminagraphic studies on Cases 3 and 4 reveal practically identical x-ray pictures. The lesion was "comma-shaped" in both instances and fingerlike projections were seen to extend from the inferior portion of the mass toward the diaphragm. The laminagram on Case 4 did not demonstrate this type of abnormality; however, it is our belief that due to mediastinal structures surrounding this cystic area, laminagraphic detail was obscured.

We do not feel that retrograde aortography is indicated when intralobular bronchopulmonary sequestration is suspected due to the possible untoward sequelae of this procedure. However, if an arteriovenous fistula of the lung is seriously considered, an angiocardiogram is indicated.

Although the true incidence of this condition is not known, we believe it to be more common than is ordinarily suspected.

The gross abnormalities of these 6 cases were uniformly similar, disregarding secondary inflammatory changes, and conformed to the pathologic pattern originally described by Pryce.[2] There was no bronchial communication demonstrated in any of our cases. The pulmonary parenchyma in the sequestered

area was described as being light pink and visibly devoid of anthracotic pigment by each of the operating surgeons. However, microscopically, anthracotic pigment was occasionally demonstrated in these areas. The pulmonary tissue between and among the cystic areas showed evidence of fibrosis and inflammatory reaction. The anomalous arteries which were stained for elastic tissue in all cases revealed that there was an abundance of elastic tissue, thus, these anomalous vessels are designated as pulmonary type arteries. Intimal sclerosis was noted in one of the anomalous vessels.

The roentgenographic appearance of 5 of these 6 cases was almost identical in location and size. Although this is not diagnostic we feel that one's index of suspicion should be high if an abnormality is encountered in this area. As was stated previously, the clinical picture may be one of repeated respiratory infections or may be completely negative. Familiarity with this condition has enabled the diagnosis to be made in 5 of our 6 reported cases.

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TRANSPLANTATION OF THE DIAPHRAGM FOR OBLITERATION OF DEAD SPACE FOLLOWING PULMONARY RESECTION

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THORACOPLASTY is the usual method of reducing the dead space following pulmonary resection, diminishing the amount of overdistention and loss of pulmonary function of the contralateral lung and of any residual homolateral segments remaining after partial resection. Although thoracoplasty does not result in appreciable external deformity when the first rib and transverse processes are preserved, we have found in practice that it is not performed routinely at the time of the primary procedure in the interest of reducing mortality and morbidity when the resection has been difficult and prolonged. When thoracoplasty is a secondary procedure, irreversible compensatory changes have usually occurred in the lung and the advantages of immediate reduction in volume of the thorax are lost. Thoracoplasty is not suitable when inferior segments are resected and may well result in bronchial torsion and impeded drainage of upper segments. Crushing the phrenic nerve for the purpose of elevating the diaphragm after lobectomy has the undesirable effect of reducing the respiratory excursion of the portion of the lung remaining, and plombage has been unsatisfactory except as a temporary measure in our hands. After suitable studies on dogs, one solution to this problem appeared to be superior transplantation of the diaphragm. A case in which the idea proved useful was that of a minister's wife, who was found to have an adenocarcinoma of the left lower lobe. This was resected, and the circumferential origin of the diaphragm was detached and sutured higher within the chest. Dead space was thus obliterated, and the patient was left with a functioning diaphragm immediately beneath the upper lobe which was not overdistended.

CASE REPORT

Following six attacks of pneumonitis over a period of one year, the patient, a housewife 68 years of age, was hospitalized in a neighboring city with fever of 101° F. and a productive cough. She was treated with penicillin and streptomycin, but the fever persisted and roentgenograms showed a left pleural effusion and a shadow at the left lateral border of the heart. This was originally interpreted to be an aneurysm of the descending aorta but finally was diagnosed as an atelectatic lower lobe. She was discharged to her home but continued to have fever which usually was not higher than 99.5° F. Also dullness to percussion, distant breath sounds, and râles persisted over the left lower chest. Postural drainage yielded a small amount of blood-streaked sputum. Up to this time the patient had lost approximately 20 pounds.

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Fig. 1.—Roentgenogram of patient on admission with atelectatic left lower lobe containing adenocarcinoma.

Fig. 2.—Lateral view following lobectomy showing accumulation of fluid beneath upper lobe and air in stomach and colon beneath elevated diaphragm.

Fig. 3.

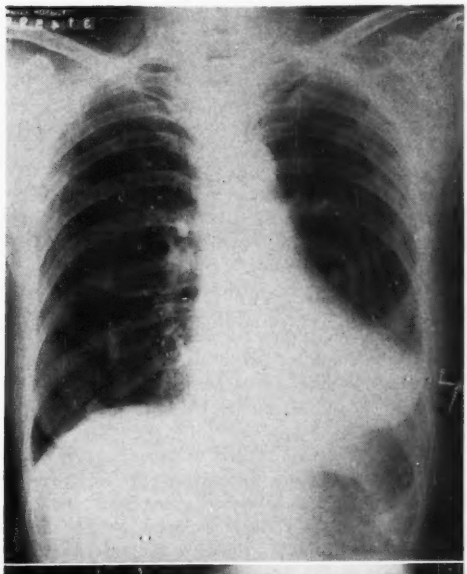

Fig. 4.

Figs. 3 and 4.—Appearance of chest five weeks later with resorption of fluid and elevation of left leaf of the functioning diaphragm. Space occupied by the eighth rib before operation is the level to which periphery of the diaphragm was transplanted.

Two months later, she was first referred to the University Hospital by Dr. J. E. Hill. On admission her blood pressure was 220/100 mm. Hg in the left arm and 218/98 mm. Hg in the right, the pulse was 78, respirations were 16 per minute, and the temperature was 99.8° F. The patient was thin, appeared to be chronically ill, and coughed frequently. However, the cough was only moderately productive. The heart was found to be enlarged 3 cm. beyond the midclavicular line; rhythm was regular, and apical systolic murmur of short duration was audible. Dullness at the left posterior and lateral base was found on percussion of the chest, and breath sounds were distant but only occasional râles were audible. A blood count showed 12 Gm. per cent hemoglobin and 14,500 white blood cells with 60 per cent polymorphonuclear leukocytes, 37 per cent lymphocytes, 1 per cent eosinophils, and 2 per cent basophils. A catheterized urine specimen was not abnormal, and an electrocardiogram showed normal sinus rhythm and no electrocardiographic evidence of cardiovascular disease. Sputum studies for neoplastic cells and pathogenic organisms were negative. Bronchoscopy revealed no intrinsic lesion, but thick mucoid secretions were found exuding from the left lower lobe, preventing adequate visualization. They were aspirated and the bronchoscope withdrawn. Following this, the patient was placed on postural drainage, and large amounts of sputum (up to 300 ml. per day) were expectorated. Although her febrile course improved, roentgenograms remained almost unchanged. A bronchogram showed failure of the segmental bronchi of the left lower lobe to fill, and operation was advised.

At thoracotomy, the lower lobe was found to be completely atelectatic and filled with mucoid material, and a lower lobectomy was easily performed since it was believed that the patient had insufficient pulmonary reserve to withstand pneumonectomy. After the fifth interspace was closed, the eighth rib was removed through the same skin incision, the periphery of the diaphragm was detached from the thoracic wall, and this free margin of the diaphragm was transplanted upward to the level of the eighth rib. The wound was then closed, leaving a fenestrated, No. 18 catheter for closed drainage of the thoracic cavity. Recovery was uneventful. Sections of the excised mass showed mucoid material throughout, and the pulmonary tissue present was compressed and reddish-brown in color. Proliferating papillary masses of epithelial cells, some of which contained mucin, were identified in sections, and a diagnosis of adenocarcinoma was made. No metastases were found in the lymph nodes removed. Other than occasional twinges of pain in the scar, the patient has had no respiratory symptoms following operation. Both cough and sputum have disappeared, and no dyspnea or digestive symptoms have been experienced subsequently. Hypertension has persisted (220/104 mm. Hg), but the patient now requires no medication and has completely resumed her normal activities three months later.

SUMMARY

Transplantation of the diaphragm upward without disturbing the function of the phrenic nerve is useful in obliterating dead space and preserving function after pulmonary resection, particularly resection of inferior segments of the lung. A case in which this method was successfully used is reported.

ADDENDUM

When the patient returned for her regular follow-up visit the following month, a small mass was found in the left breast. This proved to be adenocarcinoma with extension to axillary nodes, and a left radical mastectomy was performed. Pronounced divergence in the histologic appearance of neoplastic tissue from breast and lung favors the view that each represents a primary site but does not entirely exclude the possibility that the latter was metastatic from the former. Recovery was uneventful and without respiratory complications. Except for discomfort in the left upper quadrant of the abdomen with constipation, the patient has no complaints six months following the first operation.

AUTOTRANSPLANTATION OF SPLEEN INTO THORAX

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EXPERIMENTALLY, it has been shown that splenic tissue can be transplanted to other parts of the body and that such tissue will eventually grow in size. In the transplants, the red pulp usually predominates over the white pulp. The following case report is sufficiently unusual that we feel it is worthy of reporting. It is also interesting that this tumor could not be differentiated from a bronchogenic carcinoma until the time of surgical extirpation.

CASE REPORT

Mr. R. H. was a 29-year-old white man.

The patient stated that he had sustained a chest injury in 1945 (shrapnel wound) during World War II. At that time he had had an emergency operation and was informed that the spleen had been removed and a hole in the diaphragm had been stitched. He thought there was also some damage to the kidney. Since that time he had had periodic check-up examinations with chest films made at six-month intervals. A film made early in 1955 at the Board of Health in his community was reported as showing a "spot" in the left upper lobe. The patient was a retail lumber dealer, self-employed, working ten to twelve hours daily. He had had chronic sinusitis up until a few years previously; otherwise he considered himself essentially well. He did not smoke.

Past History.—The patient gave a history of having had pneumonia at the age of three months and a tonsillectomy in 1930.

Physical examination was essentially normal except for the presence of a healed left thoracotomy scar. The blood pressure was 120/80 mm. Hg, a complete blood count was normal with a normal blood sedimentation rate of 9 mm. in the first hour. Numerous x-rays were made of the chest and rib cage and yielded little further information except for the fact there was a spherical density, approximately 2.5 cm. in diameter, below the fourth left rib in the posterior axillary line. The outline of the mass was smooth and homogeneous. We felt it was probably in the lung, but also might involve the rib.

Previous x-ray films made in 1951 were obtained and these revealed no large tumor on the left, but there was a very faint suggestion of a beginning mass in this same area over the left third rib, though not definite. On reviewing the series of films we came to the conclusion that the lesion had been present for at least eight or nine months without much change in 1955 and *if* it was present in 1951, it was certainly very small at that time.

Preoperative diagnoses included: (1) bronchogenic carcinoma, (2) hamartoma, (3) traumatic arteriovenous aneurysm, and some of the granulomatous diseases. Surgical removal was recommended in view of the uncertainty of the diagnosis.

Operation.—On Oct. 25, 1955, a left exploratory thoracotomy was performed through a standard posterolateral approach and multiple tumors were seen on the parietal and visceral pleura, the largest being over the third and fourth ribs, posteriorly. These tumors

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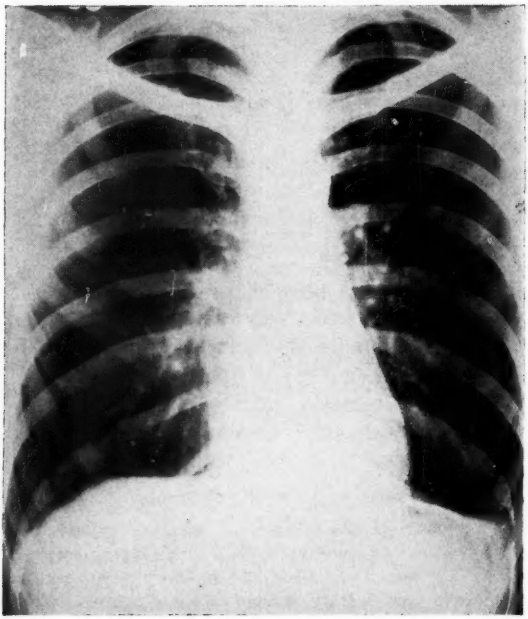

Fig. 1.—Chest film made Feb. 21, 1950, shows an essentially normal chest with no evidence of tumor.

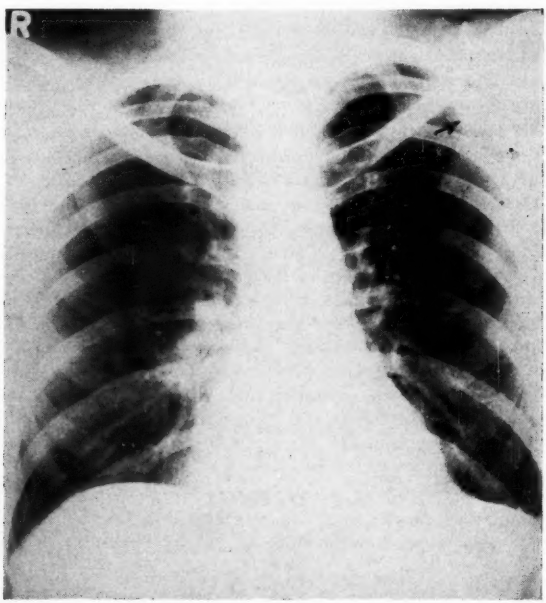

Fig. 2.—Chest film made Aug. 13, 1955. Tumor is now evident just below the fourth rib on the left posteriorly which seems to fuse with that rib. No other change is noted.

had the general appearance of liver and were soft and smooth. The diagnosis of the pathologist at the operating room consultation was probable hemangio-endothelioma but, in view of the history of shrapnel wound, transplanted spleen was very possible; and paraffin sections would be required for definitive diagnosis. It was deemed advisable to excise the remaining lesions. The third and fourth ribs were removed en bloc together with the tumor attached to them, and the remaining four smaller tumors were removed by wedge excision of a portion of the lung and from the parietal pleura. Intercostal tube drainage was employed and the wound closed in the usual manner.

The patient's postoperative convalescence was essentially uneventful.

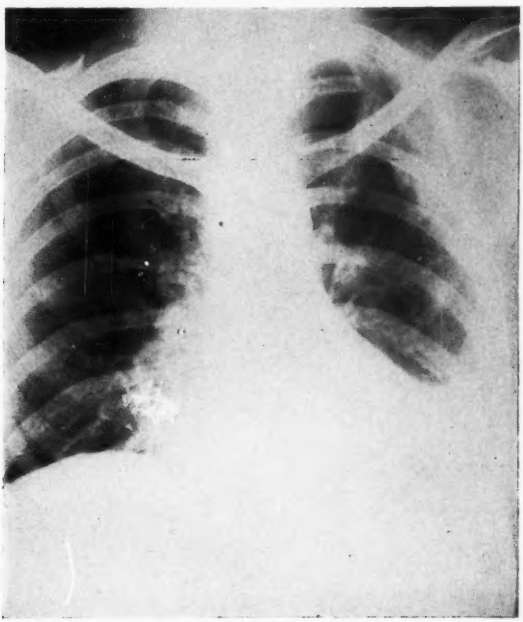

Fig. 3.—Chest film made Nov. 2, 1955, one week following surgery. This film shows a defect in the left chest wall where the third and fourth ribs have been removed together with the tumor. There is some irregular pleural reaction noted on the left side which later subsided on thoracic exercises.

Surgical Pathology.—The specimen consisted of portions of two ribs, each of which measured approximately 14 cm. in length, together with intercostal muscle and attached fibrofatty tissue. The parietal pleura was present on the inner surface of this specimen. Attached to the parietal pleura at the center of the specimen was a tumor mass measuring approximately 3.5 by 2 by 1 cm. This tumor mass was covered by a smooth, gray, fibrous capsule and was ovoid in shape. On cut section, the fibrous capsule could be seen to penetrate into the tumor mass in the form of delicate fibrous trabeculae. The bulk of the mass was made up of a soft, pulpy, red, friable tissue which scraped readily with a knife. Very tiny, white, pin-point areas were dispersed throughout this tissue. The lesion was densely adherent to the parietal pleura (Fig. 4). An additional portion of tissue consisted of an oblong-shaped fragment of lung measuring 2.5 by 1.5 by 1 cm. On one surface of this was a 9 mm. portion of encapsulated tissue identical in all respects to that just described. A third portion of tissue representing parietal pleura measured 1 by 0.8 by 0.3 cm. This third portion of tissue again had an encapsulated 5 mm. nodule similar to that described

above. A fourth and a fifth portion of tissue, representing visceral pleura, measured 1.5 by 1 by 0.5 cm. These portions of tissue had attached encapsulated structures similar to that previously described, measuring 6 mm. in diameter.

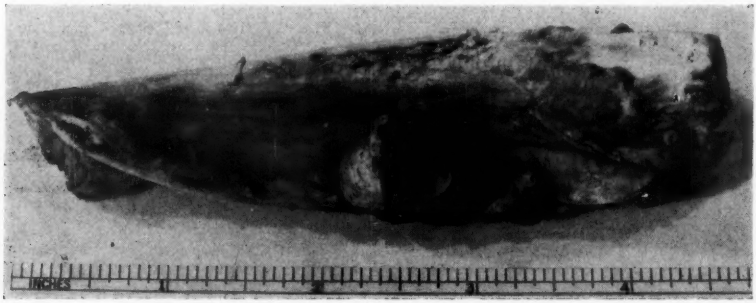

Fig. 4.—This is the gross specimen of the two resected ribs with the adherent tumor. The tumor has been split exposing its soft pulpy center.

Figs. 5-7.—Microscopic views of this tumor. Description is in the text.

Histologic study: All five portions of tissue showed an essentially similar picture except that the histologic details were best seen in the larger lesion attached to the ribs. These multiple lesions had well-defined connective tissue capsules. The connective tissue capsule in some areas was well vascularized and contained moderately large caliber arteries and veins. In the areas where the tumor came into relationship with the lung, the tumor was separated but adherent to the adjacent lung by a rather narrow zone of dense fibrous tissue. The pulmonary tissue showed dilatation of the alveoli with minimal focal areas of approximation of the alveolar walls. Macrophages, containing hemosiderin pigment, were present within the alveoli. The connective tissue capsule extended into the tumor in the

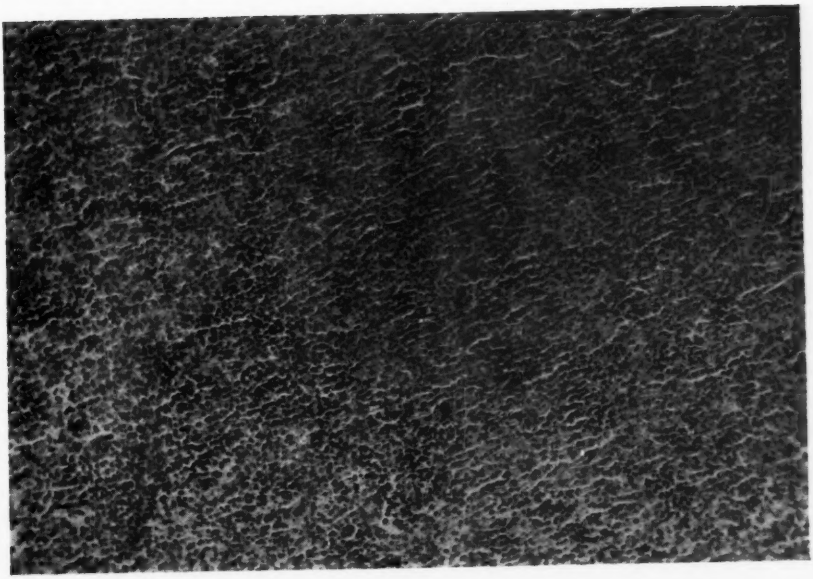

Fig. 6.

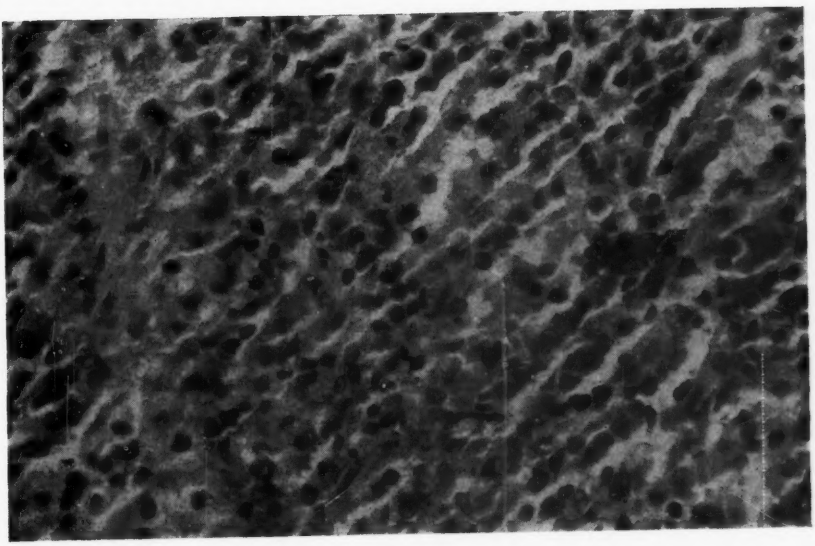

Fig. 7.

form of connective tissue trabeculae. The vascular bed, likewise, continued into the tumor and collections of lymphocytes extended parallel to the vascular penetration. Aggregates of lymphocytes or lymphatic follicles were present which very much resembled the white pulp of the spleen. These nodules were made up of lymphocytes of various sizes supported by a delicate reticular framework (Fig. 5). Occasional follicles of this nature had lymphocytopoietic centers. These lymphatic follicles were relatively few in number as compared to the great majority of the tissue making up the bulk of the lesion which had the following appearance. There were multiple venous sinuses separated by cords of tissue. These venous sinuses were lined by rod-shaped cells arranged in a parallel manner in many areas while in other areas the lining cells were of a more compressed cuboidal appearance. These sinuses contained many erythrocytes, occasional macrophages, and occasional polymorphonuclear leukocytes. The sinuses were separated by cords of cells which ran in all directions. These cords of cells were made up of nongranular leukocytes, many lymphocytes, monocytes, and macrophages. The cords of cells were identical in appearance to the splenic or Billroth cords of the spleen and the sinuses were identical to the venous sinuses of the spleen (Figs. 6 and 7). These constituent parts of the red pulp greatly predominated over the white pulp.

DISCUSSION

A survey of the literature reveals that cases of traumatic spread of splenic tissue to the peritoneum are quite rare.

Von Stubenrauch[4-6] considered that these splenic implants should be called "splenoids"; he thought that splenic autotransplants tend to regress, with the passage of time. His assumption that the peritoneum can manufacture splenic tissue is poorly supported.

Autoplastic transplantation of splenic tissue has been successful in the hands of many experimenters.

Such scattering of splenic tissue over the peritoneum following trauma is likely due to the dispersal of blood and bits of splenic pulp.

Jarcho and Anderson[1] add 2 new cases to the literature—both following trauma over the spleen. They summarize 12 other cases from the literature.

Mylander and Turrunen[2] report 3 cases of hypertension of the portal vein which were treated by transposition of the spleen into the pleural cavity in the hope that resulting adhesions and anastomoses would provide additional venous drainage. All 3 patients were in such poor condition that extensive surgical measures seemed out of the question. The results after a one- to two-year follow-up period suggested further studies concerning this method are well worth while.

We would be a little bit suspicious of this method in view of our one case of accidental transposition of the spleen into the thoracic cavity, as the spleen in our case continued to grow slowly over a period of many years. The difference in the case would be, of course, that in their case the spleen was transplanted without breaking its capsule, whereas in our case the spleen was blown into fragments and these segments were then distributed throughout the lung.

Fifteen years ago, Dr. Charles Olim and Dr. Duane Carr had a somewhat similar case at the John Gaston Hospital in Memphis. The patient had a ruptured spleen removed and several years later a rib tumor in this same area was excised and the rib itself contained splenic tissue growing within the marrow cavity. This patient also made an uneventful recovery.

SUMMARY

An unusual case is presented—the patient had a shrapnel wound of the left chest in 1945 at which time the spleen was ruptured, the kidney damaged, and perforation of the diaphragm occurred. Apparently bits of the spleen were blown up into the chest. The patient recovered from the original injury after an emergency operation and splenectomy. He had no further trouble, until films were made in 1955 that revealed a tumor in the left upper chest. In all, six splenic implants were removed from the visceral and parietal pleura and the lung tissue. Microscopically, the bits of tissue represented well-defined splenic tissue. Although the patient was asymptomatic, surgery was recommended as bronchogenic carcinoma could not be excluded from the differential diagnosis. It is of interest that in this case the red pulp of the autotransplanted splenic tissue predominated, similar to that seen in experimental transplants of splenic tissue.

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DETECTION OF INTRACRANIAL METASTASIS IN LUNG CANCER: A COMPARATIVE STUDY OF THE NEUROLOGICAL EXAMINATION AND THE ELECTROENCEPHALOGRAM

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INTRODUCTION

THE high incidence of cerebral metastases in cases of bronchogenic carcinoma has been amply documented although the reports of incidence vary somewhat. Thus, early writers such as Adler[1] and Simpson[2] reported the percentage of cerebral metastases to be 14 per cent and 13.6 per cent, respectively, while more recently King and Ford[3] reported an incidence of 27 per cent and Halpert[4] gave a figure of 32.6 per cent, all studies being based on surveys of autopsy material.

Although the incidence of cerebral metastasis during life, in a group of patients with lung cancer at an earlier stage of the disease, will be considerably lower than the incidence at autopsy, it is still of sufficient frequency to justify a careful search in the individual case. This may be of considerable importance in the preoperative evaluation of a candidate for surgical removal of a pulmonary neoplasm.

In this hospital, the routine screening of such patients has included biopsy of prescalene lymph nodes and a radiologic survey of the skeletal system. These precautions are based upon the knowledge that bronchogenic carcinoma metastasizes very frequently to these locations. Yet up to two years ago, neurological screening of these patients was elective. In most cases, a neurological clearance was requested if the patient's physician felt suspicious but not otherwise. The method of screening also varied. Some physicians specifically requested a neurological consultation, others first asked for an electroencephalogram, being satisfied if this was negative.

The assumption implicit in this second procedure seems clearly to be that the electroencephalogram in itself is an effective screening technique for the presence of intracranial lesions. It was in large part to test the validity of this assumption that the present plan of study was instituted.

METHOD

For the past two years, ward physicians throughout the hospital have been asked to refer all patients, with a diagnosis of lung tumor, for an electroencephalogram and a neurological examination. A skull x-ray was already included as part of the routine skeletal survey. Lumbar puncture was not performed routinely but only to verify suspicions arrived at by the clinical methods. In order to have as large a group as possible, it was decided to in-

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clude not only candidates for surgery but also inoperable or postoperative patients transferred from other hospitals for radiation and palliative care. Thus, both early and terminal cases were seen.

The group being reported here is not a representative sample. In the first place, despite constant vigilance and effort, not all cases of lung cancer have been seen. This is inevitable in a large hospital with the patients scattered through several wards. Second, after they have been seen many of them leave the hospital and drop out of contact. Some die at home, some move away, some are still alive. A great majority of them, of course, do return for follow-up care, but in not all of these patients who die in the hospital is autopsy permitted. Thus, of more than 80 patients examined over the two-year period of the study, a total of 27, with complete autopsy, comprise the material for this analysis. A large proportion of these represent patients seen in the last three months of life.

The question that is posed of the two screening methods here being tested is simply whether or not metastases are present in the brain. The question of localization does not arise since these patients are not usually considered candidates for craniotomy. For this simple question the closer the autopsy confirmation follows upon the screening tests the better. So the fact that the majority of this group were terminal cases is favorable for purposes of this analysis.

The neurological examinations were performed by one individual (the writer) and the electroencephalograms were interpreted by him and also independently by Dr. Knox Finley, Neurology Consultant to the hospital. The electroencephalograms were all performed by the same technician on a Grass 8 channel machine using bipolar technique with routine electrode placement over the frontal, central, occipital, and temporal areas. Both interpretations were described separately and a definite statement made as to whether the record suggested lateralized or focal pathology.

RESULTS

TABLE I. RESULTS

BRAIN PATHOLOGY PREDICTED			BRAIN PATHOLOGY FOUND (AT AUTOPSY)	
			YES	NO
EEG Clinical	Yes Yes	9	[illegible]	0
EEG Clinical	No No	[illegible]	1	[illegible]
EEG Clinical	Yes No	2	0	0
EEG Clinical	No Yes	[illegible]	5	0

These 27 cases may be divided into four categories:

I. Both clinical and electroencephalogram examination negative.
II. Both clinical and electroencephalogram examination positive.
III. Clinical examination positive and electroencephalogram negative.
IV. Clinical examination negative and electroencephalogram positive.

I. *Cases in which both clinical examination and electroencephalogram were negative:* There were 11 of these and the autopsy confirmed the ante-mortem impression in ten instances. The exception is summarized herewith.

CASE 1. The patient was a 66-year-old white man who was examined on Jan. 28, 1955, having had a pneumonectomy for small-cell carcinoma of the right lung in March, 1954. He appeared weak but had no complaints of neurological significance. He was mentally clear, walked with normal gait and showed no defects in coordination or strength of extremities. Cranial nerves were intact. The reflexes were equal. An occasional upward movement of the left great toe on the Chaddock maneuver was noted but plantar stimulation yielded a normal response. This single finding was not felt in itself of sufficient weight to make a diagnosis of metastasis. The electroencephalogram was normal. The patient was not seen again in neurological consultation but according to the progress notes of the ward physician it is clear that by the end of February he was becoming confused. He went home for a brief furlough in March and on returning to the hospital was lethargic and disoriented at intervals. He became stuporous terminally and died April 18, 1955, almost three months after the time of the neurological examination. At autopsy he had a large right temporal lobe tumor with fresh hemorrhage in its periphery.

Comment: It seems fairly certain that this patient had either not yet developed spread to the brain at the time of his neurological and electroencephalogram examinations or else (as seems likely) the tumor was then too small to have produced significant dysfunction or electrical abnormality.

II. *Cases in which both clinical examination and electroencephalogram were positive:* Of the 9 cases where both clinical examination and electroencephalogram correctly identified the presence of intracranial metastasis, there was one false localization.

CASE 2. The patient, a 54-year-old white man, entered the hospital Sept. 18, 1954, for terminal care of a carcinoma of the right lung. He had had an exploratory thoracotomy elsewhere three months earlier and an inoperable lesion was discovered. However, as early as three months before the thoracotomy, his wife reported that he had shown changes in his personal habits and she noted that he bumped into things occasionally as though he did not see them. When seen on September 27, two days before death, he was confused, disoriented, and yawned frequently. He could not cooperate well in the examination and was unable to walk, having been confined to bed ever since his chest surgery. There was no choking of the discs, no field defect, and ocular movements were normal. There were no striking abnormalities in the reflexes, motor strength, or sensation. It was the clinical impression that he had frontal lobe metastases. The skull films showed questionable erosion of the posterior clinoid process. The electroencephalogram showed bilateral frontal 4 to 6 per second waves of high amplitude, of greater prominence on the left. At autopsy he had a large tumor in the vermis of the cerebellum, extending into the vicinity of the dentate on each side. The brain was moderately swollen and there was some symmetrical ventricular enlargement, but no lesions were found in the cerebral hemispheres.

Comment: Here the terminal occurrence of edema with its consequent effect on psychologic function dominated and obscured the original lesion in the cerebellum. The electroencephalogram also falsely localized this lesion. The projection of delta waves into the frontal areas from posterior fossa lesions has been described by others.[7, 9]

III. *Cases in which the clinical examination was positive and the electroencephalogram negative:* There were 5 patients in this category. Three of

these had cerebellar tumors. In all of these cases, the localization was correctly made on clinical examination (Cases 15, 16, 18). One patient presented also with a cerebellar syndrome clinically but at autopsy did not have metastatic deposits but rather showed degenerative changes throughout the cerebellar cortex with falling out of Purkinje cells (Case 19).

The fifth case, a right frontal lobe lesion, was erroneously localized to the cerebellum on the basis of neurological findings (Case 17).

CASE 15. The patient was a 59-year-old white man who had had a pneumonectomy in October, 1955, followed by x-ray therapy. He was discharged a month after surgery essentially asymptomatic and remained well until mid-January, 1956, when he developed severe headache, felt dizzy, and became unsteady in gait. Neurological examination on Jan. 18, 1956, the day after admission, showed horizontal nystagmus on looking to the right, drifting of the outstretched left arm and slight terminal tremor on left finger-to-nose maneuver, and gross ataxia on placing left heel to right shin. He was unwilling to walk for fear of falling. The clinical impression recorded was one of left cerebellar metastasis. The electroencephalogram performed Jan. 24, 1956, contained a mixture of basic 8 to 10 per second and occasional low voltage 4 to 6 per second cycles without focal or lateralizing pattern. It was interpreted as normal to border line. The patient died on Feb. 6, 1956.

At autopsy, there was a solitary 2 by 3 cm. tumor mass in the left cerebellar hemisphere.

CASE 16. This 32-year-old white man was admitted to the Neurological Service on Oct. 17, 1955, because of severe pain radiating from the back of the neck into the right side of the head and behind the right eye. The pain had commenced about two months before his entry to the hospital and had become incapacitating in the previous ten days. On examination the chief finding was the pronounced guarding of the neck muscles, with a slight tilting of the head (often an early sign of cerebellar neoplasm). The spinal fluid, which was clear, was obtained under an initial pressure of 190 mm., with a closing pressure of 100 mm. It contained 2 cells, 79 mg. per cent protein, 2+ Pandy and the gold curve was 2234431000. Skull films were normal, and the chest film showed a nodular mass in the right hilum, "suggesting neoplasm." An electroencephalogram made one week after entry was entirely normal. The patient went downhill despite an attempt at palliation with x-ray therapy. He developed evidence of further neurological deterioration with confusion and bilateral pyramidal tract involvement, and died on Nov. 22, 1955.

At autopsy he had an epidermoid carcinoma in the right lung and multiple metastatic nodules in both cerebral hemispheres as well as a large tumor mass occupying most of the right cerebellar hemisphere and two smaller ones in the left cerebellar hemisphere.

CASE 17. This patient, a 63-year-old white man, was examined on Feb. 7, 1956, just three days before his death. He had been receiving x-ray therapy for an inoperable carcinoma of the right lung. He had noted weakness of the left foot about one week previously. He walked with steppage gait on the left and could not dorsiflex his left foot. The left ankle jerk was less active than the right and there was diminished sensitivity to pinprick over the dorsolateral aspect of the left foot and the lower lateral calf. The knee jerks were equal. The reflexes in the left upper extremity were slightly brisker than those on the right. The remainder of the examination was normal except for a rapid horizontal nystagmus, more marked on right lateral gaze. The clinical impression was of metastases to the lumbosacral roots and to the cerebellum. The electroencephalogram was normal.

At autopsy, however, there was a solitary 2 cm. rounded metastatic nodule in the central white matter of the right frontal lobe just anterior to the lateral ventricle. The spinal cord and cauda equina were not examined.

CASE 18. The patient, a 56-year-old white man, was admitted to the hospital on March 2, 1955, for investigation of a persistent cough of three months' duration. The

sputum was positive for tubercle bacilli but bronchoscopic examination revealed an obstruction. Thoracotomy was performed, at which time an inoperable lung tumor on the right was discovered. The biopsy proved it to be adenocarcinoma. Neurological examination on July 1, 1955, indicated a left cerebellar lesion manifested by nystagmus in left horizontal gaze and past-pointing with left finger-to-nose maneuver. Skull plates were negative. The electroencephalogram made on July 8, 1955, was normal. Spinal fluid obtained on July 5, 1955, was under normal pressure and contained no cells, 72 mg. protein, 1+ Pandy and gold curve of 1112210000.

The electroencephalogram was repeated Sept. 8, 1955, at which time a right temporoparietal focus was present. The patient died Dec. 11, 1955, and the autopsy showed carcinoma of the upper lobe of the right lung, a large necrotic semicystic metastasis occupying about one half of the left cerebellar hemisphere and a 5 cm. lesion in the right parietal lobe.

CASE 19. This 61-year-old white patient was admitted to the hospital Oct. 18, 1955, for investigation of cough, weakness, and weight loss of three months' duration. On admission, he had physical signs and x-ray evidence of a mass in the right upper lung. He walked with a wide base, showed nystagmus on horizontal gaze, more marked to the left than the right, and performed the heel-to-shin maneuver with marked ataxia. The electroencephalogram was normal. Spinal fluid was under normal pressure and contained 3 lymphocytes, protein of 30 mg. per cent, negative Kolmer, and colloidal gold curve 0111100000.

He deteriorated steadily and died March 14, 1956. At autopsy, there was found an adenocarcinoma of the right lung. The brain was grossly normal, but the cerebellum showed diffuse falling out of Purkinje cells, the remaining Purkinje cells showing chronic degenerative changes.

Comment: The cerebellar degeneration in this patient probably falls into the group of carcinomatous degenerations of the central and peripheral nervous system which has recently been described in the literature.[10]

IV. *Cases in which the clinical examination was normal and the electroencephalogram abnormal:* There were 2 such cases. In both instances, the patients were terminal, cachectic, eating poorly, and requiring large doses of analgesic medication. The abnormality in the records was not sleep artefact but may have been attributable in part to metabolic and electrolyte disorders associated with the terminal phase of cancer. The records both showed bursts of diffuse 2 to 3 per second and some 5 to 7 per second slow waves and presented sufficient asymmetry to suggest lateralization of pathology to the two independent interpreters. The gross and histologic appearance of the brains was normal, however. In both these cases, the neurological opinion was that no metastatic brain lesions were present.

COMMENT

Of the entire group of 27 autopsied cases, there were 15 with intracranial disease. Fourteen of these were detected by the neurological examination during life, while 9 of them had electroencephalographic abnormalities of focal type. It is apparent that the incidence of central nervous system metastases in this small group is preternaturally high—52 per cent in contrast to the 14 to 32 per cent range cited above.[1-4] The reason for this cannot be definitely stated, but some of the following factors may enter in. Hospitalization is readily available to veterans. These patients are followed closely in a surgical

outpatient clinic throughout their postoperative course as long as they remain in easy traveling distance. While some may prefer to spend their terminal stages at the family home, this is probably less likely to be true for those who develop cerebral metastases, since they often become difficult to care for at home. Hence, a greater relative proportion of this group return to the hospital and the autopsy statistics are correspondingly "loaded."

Of the 6 cases missed by the electroencephalogram, one was also missed on the neurological examination (Case 1) and, as has been pointed out, this is probably because the lesion was incipient when the patient was first seen. The other 5 were clear misses for the electroencephalogram, since the clinical opinion at the same time as the electroencephalogram correctly favored the presence of intracranial masses. Four of these were posterior fossa lesions. It has been stressed by various writers that this is a "blind spot" for the electroencephalogram.

Smith and associates[5] reported a pattern, which they felt was diagnostic of subtentorial tumor, consisting of delta waves over the occipital leads. Others have not found this to be a consistent pattern.

Rheinberger and Davidoff,[6] after reviewing a group of subtentorial tumors in adults, concluded that, "There is no pattern or distribution of electrical abnormality specifically indicative of posterior fossa disturbance."

Pupe and co-workers[7] pointed out that in the presence of posterior fossa tumors the electroencephalogram may point either to the midline or to the cerebral hemispheres.

Daly[8] reported a large series (66) of verified posterior fossa tumors studied by electroencephalogram and came to the conclusion that there was no predictable correlation between the site of the electroencephalographic abnormality and the anatomic site of the lesion. They found, as had Cuneo and his co-workers,[9] that the most commonly observed pattern was one of rhythmic bilaterally synchronous slow waves. Eighteen per cent of the cerebellar tumors in Daly's series presented normal electroencephalographic records.

The sixth case with a "false negative" electroencephalogram (Case 17) was a deep anterior frontal lobe nodule and the normal electroencephalogram only three days before death should serve to emphasize again that there are other silent areas for this test besides the posterior fossa. In this case, there was no significant edema of the brain on the side of the tumor and this, plus its deep location, probably accounts for the normal electrical activity from the overlying frontal cortex.

The embarrassing and familiar error of confusing tumor of the frontal lobe and the cerebellum was made twice on clinical grounds and in both possible directions (Cases 7 and 17). The electroencephalogram compounded the error in the first of these.

Finally, it may be of interest (though aside from the main purpose of the study) to point out that in the course of this screening, 4 patients were found to have evidence of brain metastases who would be otherwise considered operable for their lung tumor. The statistical significance of this figure (4 out

of 27) should probably be discounted, since it has been pointed out that the entire group was more heavily represented by terminal than by early stages of the disease. But it is worth repeating that in these 4 there was no other evidence of metastasis and the lung tumor itself appeared operable so that the patient was considered in all other respects an entirely suitable candidate for surgery. In 3 of these the neurological symptoms were prominent and could scarcely have been overlooked by any physician taking a routine history. In one, however, no specific neurological complaints were offered and the diagnosis was made upon the objective findings of the neurological examination supported by the electroencephalogram.

CONCLUSIONS

In a group of 27 cases of bronchogenic carcinoma studied during life both by clinical neurological examination and electroencephalogram, and with complete autopsy, brain involvement occurred in 15. The neurological examination failed to predict involvement in only one of these cases, while the electroencephalogram missed 6 (4 of them in the cerebellum).

In 2 additional cases where the brain was uninvolved, the electroencephalogram suggested lateralized intracranial abnormality while the neurological examination was normal.

In 4 of the patients who presented clinical evidence of brain involvement, this was the only apparent indication that the disease had spread beyond the lung.

This study indicates the value of a careful neurological evaluation of prospective candidates for removal of a malignant lung tumor. It seems clear, moreover, that while the electroencephalogram is a useful aid in confirmation it should not be depended upon in itself as a screening technique.

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RIBBON ESOPHAGOSCOPES

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THE first ribbon esophagoscope was designed to solve a specific problem in handling an esophageal stricture in a patient after all other treatment had failed.[1] After working with the instrument over a period of time, it soon became apparent that a tube of this shape had many advantages for the operator doing diagnostic and operative instrumentation.

A set of two of these esophagoscopes is presented here in the belief that they will be a true addition to the armamentarium of the surgeons doing thoracic work.

THE INSTRUMENTS

The barrel of the new esophagoscope is a flat oval in shape to take advantage of the fact that the esophagus may be stretched from side to side more than it can in the anterior-posterior diameter. The extreme flattening of the barrel results in less laryngeal stimulation from pressure and hence less trouble with coughing and gagging during instrumentation. The barrels are 51.5 cm. and 29.5 cm. in length. The inside diameters are 9 by 19 mm.

The light carrier is on the side of the barrel again taking advantage of the fact that the esophagus dilates more easily from side to side, thus a full lumen is obtained. It may be withdrawn and replaced by the operator if the light becomes clouded.

At the proximal end of the esophagoscope there is incorporated a light trap, 6.6 cm. in length. This makes it possible to work in a brightly lighted room without interference with the operator's visual accommodation.

The electric power supply is incorporated into the handle of the instrument; thus doing away with the proverbial nuisance of wires, and obtaining a constant power supply which will not burn out the light bulb in the midst of instrumentation.

An advantage of the width of this barrel, especially to those men frequently dealing with carcinoma, is that the biopsy forcep may be passed diagonally from proximal to peripheral end of the scope so that the business end of the biopsy forceps is under direct observation when the specimen is obtained.

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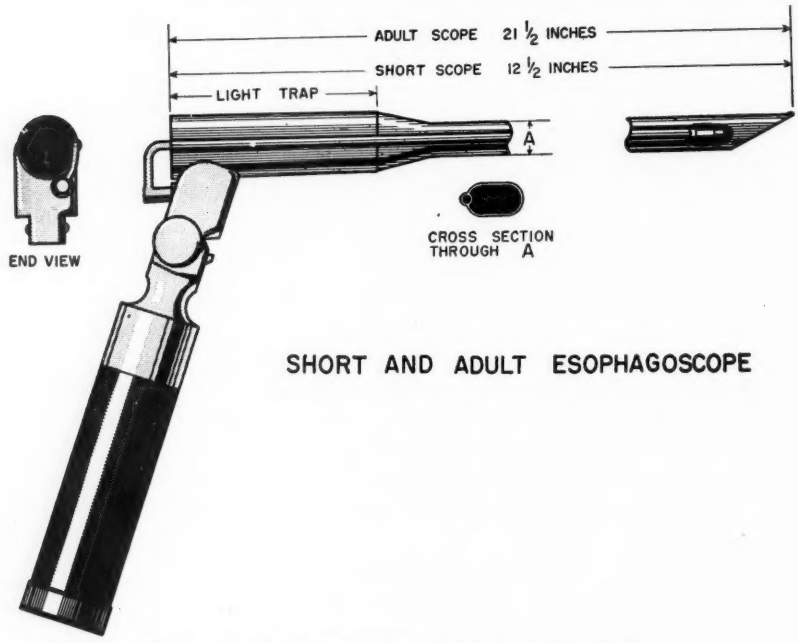

Fig. 1.—Diagrammatic drawing of ribbon esophagoscopes.

CONCLUSION

A brief presentation of a new ribbon esophagoscope* has been made.

It has been found to be satisfactory for the purpose for which it was designed.

Certain advantages inherent in such a scope have been pointed out, such as, ease and safety of insertion, no free wires to entangle operator or his aide, light trap, and diagonal instrumentation.

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*The ribbon esophagoscopes are available to the profession at Welch Allyn, Inc., Skaneateles Falls, New York.

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ANNUAL MEETING NOTES

The Thirty-seventh Annual Meeting of The American Association for Thoracic Surgery was held in Chicago, Illinois, on May 4, 6, and 7, 1957. There were 1,001 physicians who registered for the scientific sessions. In addition, there were 182 wives present.

As a mark of esteem and appreciation for the close contact that has been maintained between The American Association for Thoracic Surgery and the Society of Thoracic Surgeons of Great Britain and Ireland, the latter group proffered a Presidential Badge and Chain of Office. In an appropriate ceremony, held immediately at the conclusion of the Business Session on Saturday, May 4, 1957, Mr. George A. Mason, Vice-President of the Society of Thoracic Surgeons of Great Britain and Ireland, presented this gift to our Association. Mr. J. Leigh Collis, the Honorary Secretary, placed the ornament about the neck of Dr. Cameron Haight, the President. The other distinguished representatives were Professor R. S. Pilcher, Mr. Vernon C. Thompson, and Mr. Oswald S. Tubbs.

At the conclusion of the Scientific Session on Tuesday afternoon, May 7, the precedent was established wherein this Presidential Badge and Chain of Office was vested upon the incoming President by the retiring officer of similar rank.

The problems presented by the rapid growth of this Association were studied at great length by an especially appointed committee of which Dr. Edward M. Kent was the Chairman. The proposals advanced in the report of this committee were thoroughly discussed by the membership in Executive Session. In view of the crucial character of any such decision this committee was requested to pursue further its investigation and report the results of such deliberations at a future date.

The following changes in membership status were voted by the Association during its annual Executive Session:

The following Active members were elevated to Senior Status:

Robert G. Bloch
Louis R. Davidson
Harry R. Decker
Louis F. Knoepp
Leon J. Leahy
Herbert Willy Meyer
Richmond L. Moore
M. Dawson Tyson
Joseph A. Weinberg

The following Associate members were elected to Active membership:

Ralph D. Alley
Frank S. Ashburn
Frank Bortone
Garrett M. Brownrigg
John S. Chambers, Jr.
John G. Chesney
George H. A. Clowes, Jr.
David A. Cooper
Oscar Creech, Jr.
Albert C. Daniels
DeWitt C. Daughtry
Norman C. Delarue
Emerson H. Drake
F. Henry Ellis, Jr.
William B. Ford
Theodore R. Hudson
Gerard A. P. Hurley
Elliott S. Hurwitt
Fred J. Jarvis
James H. Johnston, Jr.
John L. Keeley
James R. Laurey
Sanford E. Leeds
William P. Longmire, Jr.
Waldo O. Mills
Emmanuel M. Papper
Richard M. Peters
Beatty H. Ramsey
Charles T. Read
Irving A. Sarot
Joseph E. Strode
William R. Waddell
James H. Walker
Watts R. Webb
Julius L. Wilson
Thomas B. Wiper

The following candidates were elected to Associate membership:

Thomas G. Baffes, Chicago, Ill.
James S. Battersby, Indianapolis, Ind.
Martin Bergmann, St. Louis, Mo.
Philip E. Bernatz, Rochester, Minn.
William G. Cahan, New York, N. Y.
Richard G. Connar, Tampa, Fla.
John F. Dammann, Charlottesville, Va.
Robert A. DeBord, Peoria, Ill.
Josiah Fuller, Duluth, Minn.
William W. L. Glenn, New Haven, Conn.
Laurence K. Groves, Cleveland, Ohio
Owen Gwathmey, Washington, D. C.
Joseph M. Hanner, San Diego, Calif.
Edward J. Jahnke, Jr., Washington, D. C.
Robert W. Jamplis, Palo Alto, Calif.
Robert J. Jensik, Chicago, Ill.
Frank R. Johnston, Winston-Salem, N. C.
Robert P. McBurney, Memphis, Tenn.
Peter V. Moulder, Chicago, Ill.
Wilford B. Neptune, Boston, Mass.
John S. Paul, Martinsburg, W. Va.
John W. Polk, Springfield, Mo.
Herbert T. Ransdell, Jr., Louisville, Ky.
David H. Watkins, Denver, Colo.

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